

# USDA progress toward developing HLB-tolerant/resistant Citrus scions



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<u>Cultivar</u>	<u>Cross/Nucellar seeding/Irradiation</u>	<u>Release</u>
Minneola/Orlando/Seminole	1908-12 Swingle/Savage	1931 Swingle/Robinson/Savage
Lee/Osceola/Robinson	1942 Gardner/Bellows	1959 Reece/Gardner
Nova/Page	1942 Gardner/Bellows	1963-4 Reece/Gardner/Hearn
Fairchild/Fortune/Fremont	~1960 Furr	1964 Furr
Bower	1942 Gardner/Bellows	1973 Wutscher
Sunburst	1961 Reece	1979 Hearn
Fallglo/Ambersweet	1962-3 Reece/Hearn	1987 Hearn
Flame	1973 Wutscher/Hearn*	1987 Hearn
Midsweet	1960 Reece	1987 Hearn
US Early Pride	1991 Hearn	2009 McCollum/Hearn
US Seedless Pineapple	1970 Hearn	2009 McCollum/Hearn
US Furr/Furr ST	1953 Reece	2014 Stover et al
US Seedless Surprise	1964 Furr	2017 Stover et al
US Ortanique LS	1998 Chaparro	2018 Stover et al
US HoneyCoat	1973 Hearn	2018 Stover et al
US 7650, 7651, and 7652	1995-96 Hearn	2018 Stover et al
US SunDragon	1999 Chaparro	2018 Stover et al
US Superna	1966 Hearn	2019 Stover et al

- ~29 cultivar releases. 17-63 years between cross & release. From Hearn retirement 1995 until 2009- no releases or even replicated trials established!
- Initially the wisdom was that HLB would kill ALL citrus. We identified some HLB-tolerance in 2009, made first crosses for HLB-tolerance in 2010.

Hybridizations: More than 26,000 unique hybrids produced in last 10 years

- **Majority focused on HLB resistance/tolerance. sweet-orange-like, red GF, and Seedless Mandarins, all focusing on fruit quality with HLB tolerance, and emphasizing advanced selections as parents.**
- 2010-2015: >6500 flowers from >320 parental combinations
- 2016: 1316 flowers from 40 parental combinations
- 2017: 1700 flowers from 83 parental combinations
- 2018: 4000 flowers from 120 parental combinations
- 2019: 1511 flowers from 52 parental combinations
- **We now have >19,000 new hybrids in the ground with more in greenhouses.**

Hybrids are placed in field and evaluated for HLB, fruit & hort quality,

- Evaluating and selecting from previous generations as well as new hybrids
- Selections with potential as cultivars are sent to DPI and placed in second tests with growers and in USDA farms
- Used as parents along with good selections not suited as cultivars

We have been making hybrids and putting them into the field to create resistant/tolerant scions AND to test genes/expression that will accelerate further conventional and biotech work- 55 unique crosses in 2019

FF	2019	P	Bower	Clementine x Orlando	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	AA	FF-1-5-35	Ambersweet x FF-1-57-105?	FF-1-88-113	Ftp-6-32-67 x Kishu
Ftp	2019	X	FF-1-5-35	Ambersweet x FF-1-57-105?	Ftp-6-68-134	Ftp-6-46-130 x Ftp-6-9-96
Ftp	2019	Z	FF-1-5-35	Ambersweet x FF-1-57-105?	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96
FF	2019	E	FF-1-74-52	Ambersweet x Tresca	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF	2019	Q	FF-1-81-193	FF-1-37-12 x Y1	FF-1-88-113	Ftp-6-32-67 x Kishu
FF	2019	R	FF-1-81-193	FF-1-37-12 x Y1	Ftp-6-1-41	Fallglo x Kishu
FF	2019	F	FF-1-83-179	FF-1-22-80 x FF-5-75-8	Ftp-4-4-1	FF-1-77-19 x FF-5-62-17
Ftp	2019	10	FF-1-8-70	(FF1-20-68 X FF-5-16-78)	Ftp-6-1-41	Fallglo x Kishu
Ftp	2019	I	FF-1-8-70	(FF1-20-68 X FF-5-16-78)	FF-1-88-113	Ftp-6-32-67 x Kishu
FF	2019	N	FF-1-88-71	Ftp-6-32-67 x Kishu	FF-1-88-113	Ftp-6-32-67 x Kishu
FF	2019	O	FF-1-88-71	Ftp-6-32-67 x Kishu	FF-1-88-82	Ftp-6-32-67 x Kishu
Ftp	2019	9	FF-5-51-2	Clementine x Orlando	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF	2019	A	FF-5-7-36	Ftp-6-46-129 x FF-1-76-50	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF	2019	D	FF-5-7-36	Ftp-6-46-129 x FF-1-76-50	FF-1-5-35	Ambersweet x FF-1-57-105?
FF	2019	G	FF-5-7-36	Ambersweet x Tresca	FF-1-75-55	((FF-6-10-124 x us-119) x FF-1-11-7)
FF	2019	I	FF-5-7-36	Ftp-6-46-129 x FF-1-76-50	FF-1-61-133	Ftp-6-16-29 x US-119
FF	2019	B	FF-5-9-45	Ftp-6-46-129 x FF-1-30-52	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF	2019	C	FF-5-9-45	Ftp-6-46-129 x FF-1-30-52	FF-1-5-35	Ambersweet x FF-1-57-105?
Ftp	2019	12	Ftp-6-32-118	Ftp-6-46-129 x FF-1-76-50	Ftp-6-47-55	FF-5-14-96 x Y1
Ftp	2019	13	Ftp-6-32-118	Ftp-6-46-129 x FF-1-76-50	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96
Ftp	2019	J	Ftp-6-32-118	Ftp-6-46-129 x FF-1-76-50	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	O	Ftp-6-32-118	Ftp-6-46-129 x FF-1-76-50	Ftp-6-9-96	Med Sweet x Pineapple II

# More 2019 crosses

Ftp	2019	P	Ftp-6-32-118	Ftp-6-46-129 x FF-1-76-50	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96
Ftp	2019	1	Ftp-6-32-171	Ftp-6-46-129 x FF-1-76-50	Ftp-6-49-96	FF-5-14-96 x FF-1-11-7
Ftp	2019	11	Ftp-6-32-67	FF-1-29-105 x FF-1-11-61	Ftp-6-1-41	Fallglo x Kishu
Ftp	2019	16	Ftp-6-32-67	FF-1-29-105 x FF-1-11-61	Ftp-6-1-41	Fallglo x Kishu
Ftp	2019	14	Ftp-6-47-9	FF-5-14-96 x Y1	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	5	Ftp-6-47-9	FF-5-14-96 x Y1	FF-1-61-133	Ftp-6-16-29 x US-119
Ftp	2019	7	Ftp-6-47-9	FF-5-14-96 x Y1	FF-1-85-119	FF-1-22-122 x US-119
Ftp	2019	A	Ftp-6-47-9	FF-5-14-96 x Y1	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	H	Ftp-6-47-9	FF-5-14-96 x Y1	FF-1-75-55	Ambersweet x FF-1-30-52
Ftp	2019	L	Ftp-6-47-9	FF-5-14-96 x Y1	FF-1-74-14	Ambersweet x US-119
Ftp	2019	W	Ftp-6-47-9	FF-5-14-96 x Y1	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96
Ftp	2019	Y	Ftp-6-47-9	FF-5-14-96 x Y1	FF-1-88-113	Ftp-6-32-67 x Kishu
FF	2019	H	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-85-119	FF-1-22-122 x US-119
FF	2019	J	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-85-124	FF-1-22-122 x US-119
FF	2019	K	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-10-1	WBS-96-1 X FF-5-16-78
FF	2019	L	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-88-71	Ftp-6-32-67 x Kishu
FF	2019	M	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-81-193	FF-1-37-12 x Y1
Ftp	2019	3	Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	FF-1-85-124	FF-1-22-122 x US-119
Ftp	2019	4	Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	FF-1-5-213	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	6	Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	FF-1-85-119	FF-1-22-122 x US-119
Ftp	2019	C	Ftp-6-58-17	FF-1-57-105 x Ftp-6-49-96	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	M	Ftp-6-58-17	FF-1-57-105 x Ftp-6-49-96	Ftp-6-9-96	Med Sweet x Pineapple II
Ftp	2019	Q	Ftp-6-58-17	FF-1-57-105 x Ftp-6-49-96	FF-1-85-119	FF-1-22-122 x US-119
Ftp	2019	B	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	F	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96	FF-1-75-55	Ambersweet x FF-1-30-52
Ftp	2019	S	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96	FF-1-85-119	FF-1-22-122 x US-119
Ftp	2019	U	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96	Ftp-6-68-44	Ftp-6-46-130 x Ftp-6-9-96
Ftp	2019	D	Ftp-6-58-45	FF-1-57-105 x Ftp-6-49-96	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp	2019	G	Ftp-6-58-45	FF-1-57-105 x Ftp-6-49-96	FF-1-75-55	Ambersweet x FF-1-30-52
Ftp	2019	N	Ftp-6-58-45	FF-1-57-105 x Ftp-6-49-96	Ftp-6-9-96	Med Sweet x Pineapple II
Ftp	2019	T	Ftp-6-58-45	FF-1-57-105 x Ftp-6-49-96	FF-1-85-119	FF-1-22-122 x US-119
Ftp	2019	V	Ftp-6-68-134	Ftp-6-46-130 x Ftp-6-9-96	Ftp-6-58-35	FF-1-57-105 x Ftp-6-49-96

## Last ten years as female: Ftp-6-49-96 (Gnarlyglo) released as SunDragon- HLB-tolerant and Poncirus in pedigree

Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	Des 4 Saisons	Lemon selection
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	Early Gold	Early Gold orange
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-10-1	WBS-96-1 X FF-5-16-78
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-4-12	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	FF-1-5-213	((FF-6-10-124 x us-119) x FF-1-11-7)
Ftp-6-49-96	(FF-6-10-124 x us-119) x FF-1-11-7	FF-1-5-35	Ambersweet x probably 1-57-105
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-74-14	Ambersweet x US-119
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-76-51	Ambersweet x FF-1-30-52
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-81-193	FF-1-37-12 x Y1
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-85-119	FF-1-22-122 x US-119
Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	FF-1-85-124	FF-1-22-122 x US-119
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-1-88-71	Ftp-6-32-67 x Kishu
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	FF-6-16-32	Citron Selection
Ftp-6-49-96	(FF-6-10-124 x us-119) x FF-1-11-7	Flame	Flame grapefruit
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	Ftp-6-46-15	(6-4-49 X 1-3-18) 6-4-49= NE x Succory 1-3-18 = (Temple x Orlando) x Hamlin
Ftp-6-49-96	FF-5-14-96 x FF-1-11-7	Ftp-6-47-9	FF-5-14-96 x Y1
Ftp-6-49-96	(FF-6-10-124 x us-119) x FF-1-11-7	Ftp-6-9-96	MS x Pineapple2
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	Kunembo	Kunembo tangor
Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)	Valencia	Valencia Orange

# Last ten years as female : FF-5-51-2 one of most tolerant conventional mandarin-types

FF-5-51-2	Clementine x Orlando	kishu	Seedless Kishu from Ftp greenhouse
FF-5-51-2	Clementine x Orlando	Ftp-6-49-96	(FF-6-10-124 x us-119) x FF-1-11-7
FF-5-51-2	Clementine x Orlando	FF-1-46-30	Fallglo x FF-6-15-150
FF-5-51-2	Clementine x Orlando	FF-1-77-105	Ambersweet x FF-1-7-38
FF-5-51-2	Clementine x Orlando	Ftp-6-1-41	Fallglo x Kishu
FF-5-51-2	Clementine x Orlando	FF-1-19-21	FF-1-7-38 x FF-5-6-53
FF-5-51-2	Clementine x Orlando	FF-1-19-21	(FF-1-7-38 x FF-5-6-53)
FF-5-51-2	Clementine x Orlando	FF-1-19-58	(FF-1-7-38 x FF-5-6-53)
FF-5-51-2	Clementine x Orlando	FF-6-16-32	Citron Selection
FF-5-51-2	Clementine x Orlando	Ftp-6-49-96	FF-5-14-96 x FF-1-11-7
FF-5-51-2	Clementine x Orlando	C. Latipes	khasi papeta
FF-5-51-2	Clementine x Orlando	Rangpur	mandarin x lemon?
FF-5-51-2	Clementine x Orlando	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF-5-51-2	Clementine x Orlando	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF-5-51-2	Clementine x Orlando	FF-1-57-105	Temple x Orlando
FF-5-51-2	Clementine x Orlando	Ftp-6-32-78	1-29-105 x FF-1-11-61 = (FF-6-1-67 x orlando) X ((Robinson x clementine) x (Lee x Orlando))
FF-5-51-2	Clementine x Orlando	Ftp-6-37-170	FF-1-21-61 x FF-1-7-38 = (temple x orlando) X (FF-6-1-67 x Y1) Y1=cpb4481 =((duncan x P.trifoliata) x OP)
FF-5-51-2	Clementine x Orlando	Ftp-6-37-170	FF-1-21-61 x FF-1-7-38 = (temple x orlando) X (FF-6-1-67 x Y1) Y1=cpb4481 =((duncan x P.trifoliata) x OP)

Last ten years as female:FF-1-76-51 mono-embryonic sweet-orange-like hybrid,  
released for breeding

FF-1-76-51	(Ambersweet x FF-1-30-52)	Ftp-6-49-96	((FF-6-10-124 x us-119) x FF-1-11-7)
FF-1-76-51	Ambersweet x FF-1-30-52	FF-6-23-29	1169 x Y1
FF-1-76-51	Ambersweet x FF-1-30-52	Ftp-6-47-117	(5-14-96 X Y1) = ((Northeast Pummelo x (Duncan x trifoliata) X (((Duncan x P. trifoliata) x succory) X Y1)
FF-1-76-51	Ambersweet x FF-1-30-52	Ftp-6-45-137	6-4-49 X 1-3-18 6-4-49= NE x Succory 1-3-18 = (Temple x Orlando) x Hamlin
FF-1-76-51	(Ambersweet x FF-1-30-52)	Ftp-6-47-117	(5-14-96 X Y1) = ((Northeast Pummelo x (Duncan x trifoliata) X (((Duncan x P. trifoliata) x succory) X Y1)
FF-1-76-51	(Ambersweet x FF-1-30-52)	FF-1-10-1	WBS-96-1 X FF-5-16-78
FF-1-76-51	(Ambersweet x FF-1-30-52)	FF-1-75-55	Ambersweet x FF-1-30-52 (wilking x valencia)
FF-1-76-51	(Ambersweet x FF-1-30-52)	Hamlin	Hamlin Orange
FF-1-76-51	(Ambersweet x FF-1-30-52)	FF-6-23-29	1169 x Y1
FF-1-76-51	(Ambersweet x FF-1-30-52)	FF-1-10-90	(WBS-96-1 X FF-5-16-78)
FF-1-76-51	Ambersweet x FF-1-30-52	FF-1-85-119	FF-1-22-122 x US-119
FF-1-76-51	Ambersweet x FF-1-30-52	Cipo	Cipo Orange
FF-1-76-51	Ambersweet x FF-1-30-52	Ftp-6-47-9	FF-5-14-96 x Y1
FF-1-76-51	Ambersweet x FF-1-30-52	FF-1-5-213	FF-5-14-96 x FF-1-11-7
FF-1-76-51	Ambersweet x FF-1-30-52	FF-1-74-14	Ambersweet x US-119



# Selections made

## **Selections are made as potential cultivars and parents for future cvs.**

- 2011-2013: 24 selections with evidence of HLB-tolerance, some sweet-orange-like and high quality mandarins.
- 2014: 32 new selections of which 20 are Kishu hybrids. 3 are no to low-seeded mandarin selections which may have immediate potential as cultivars. Low-seeded Fortune x Encore (1-22-79 irr 1-42-65)!!
- 2015: 28 new hybrids selected for use as breeding parents; widely varied backgrounds with good levels of tolerance to HLB as well as other potentially useful traits. Substantial number are orange-like
- 2016: 16 seedless Kishu hybrids, **8 HLB-tolerant sweet orange-like**, 2 GF-like, 1 excellent tasting seedy mandarin
- 2017: 15 seedless Kishu hybrids; 1 mandarin w/ excellent color; **5 HLB-tolerant sweet-orange-like hybrids containing Poncirus**; 1 Tangor derived from Poncirus; a lime-like fruit containing Poncirus; **seedless 1-75-55**
- 2018: 33 new selections including 3 low seed irradiated versions of Ftp-6-32-67 which is a high quality, sweet tasting mandarin selection with excellent color. **Six selections of orange-like trifoliolate hybrids with early flowering backgrounds will be used to produce HLB tolerant Orange-like selections.** Several new seedless Kishu hybrids. **Four new selections of SunDragon hybrids which appear to have improved tolerance to HLB and very low trifoliolate off taste**

Comparison of 50 Selections and Cultivars at Picos Farm:  
May be excessive challenge: no-choice ACP, ACP house,  
then field.

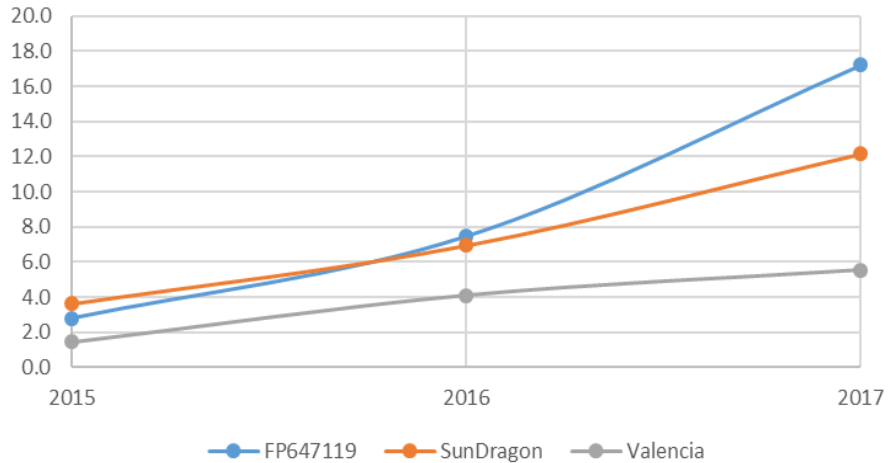
At 5.5 yrs in field some are quite healthy and have grown well, while others are sickly and stunted.



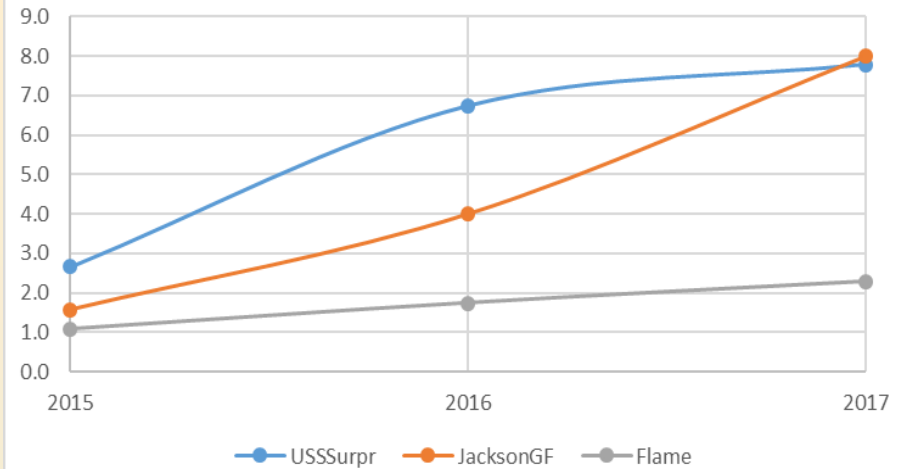
## After 5.5 years in Ground: Tolerance observed from mandarin and Poncirus hybrids

		Canopy density (%)	Tree health (5 is best)	Canopy vol (m <sup>3</sup> )	Canopy vol RGR (%)
FF1-42-70	Fortune x Encore	98.3 a	5.0 a	10.9 b-g	94 a-k
Bower	Clem x Orlando	98.0 a	4.8 a-c	9.3 c-i	103 a-g
FP6-47-119	Orange-like w/Pt	97.5 ab	4.6 a-e	17.2 ab	128 a-c
FF1-4-2	Complex w/Pt	97.0 ab	4.2 a-g	19.9 a	114 a-e
FF1-34-11	5-51-2 x 1-57-105	96.7 a-c	4.8 ab	6.6 c-j	98 a-i
Nova		96.0 a-c	3.9 a-h	3.0 h-j	51 d-o
JacksonGF		95.0 a-c	4.3 a-f	8.0 c-j	95 a-k
Clementine		94.0 a-c	4.6 a-e	7.0 c-j	144 a
FP6-49-116	SunDragon-sib	93.3 a-c	4.6 a-e	13.7 a-c	84 a-m
SunDragon		93.0 a-c	4.6 a-e	12.2 b-e	79 a-n
Valencia		90.0 a-c	4.1 a-g	5.5 d-j	28 i-o
US119	Complex w/Pt	88.8 a-c	4.6 a-e	6.6 c-j	102 a-h
FF5-51-2	Clem x Orlando	88.8 a-c	3.8 a-h	3.0 h-j	80 a-n
Temple		85.0 a-d	3.5 a-i	4.8 f-j	33 g-o
USEarlyPride		82.5 a-d	4.1 a-g	5.7 d-j	117 a-d
Carrizo		75.0 a-e	3.9 a-h	4.9 e-j	36 f-o
Flame		55.0 ef	2.0 ij	2.3 ij	26 j-o
Sunburst		53.8 ef	3.1 d-i	1.7 j	10 no
USSurprise		50.0 f	2.8 f-j	7.8 c-j	8 o

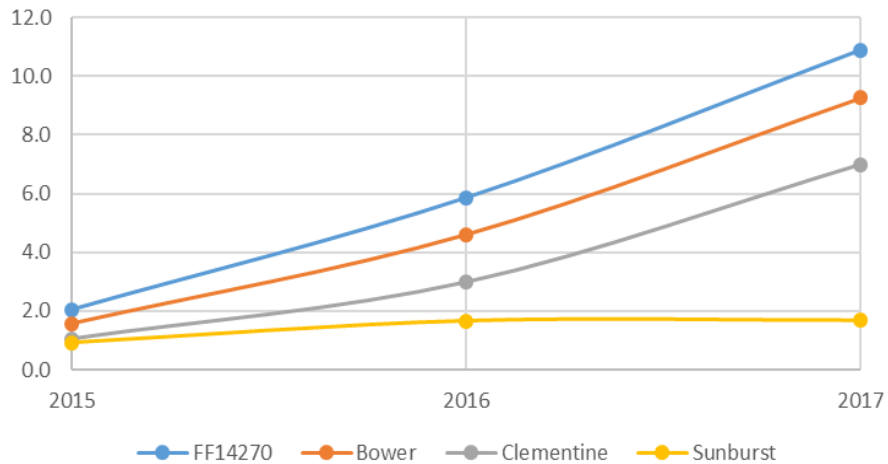
Growth of Sweet Orange Types



Growth of Grapefruit Types



Growth of Mandarin Types



**Change in canopy volume (m<sup>3</sup>) in trial of 50 selections/cultivars**

**Trees no choice inoc with CLAs, and ACP house before field**

**Trial planted Jan 2014, data collected Nov of each year**

**Relative growth rate may be best early evidence of tolerance**

**Using sweet orange-like hybrids aggressively as breeding parents- Next generations of hybrids in field**



*Newly released*

*First released scion containing  
Poncirus for use as fresh fruit.*

*Also breeding parent*

## US SunDragon

Like Navel in alligator-hide

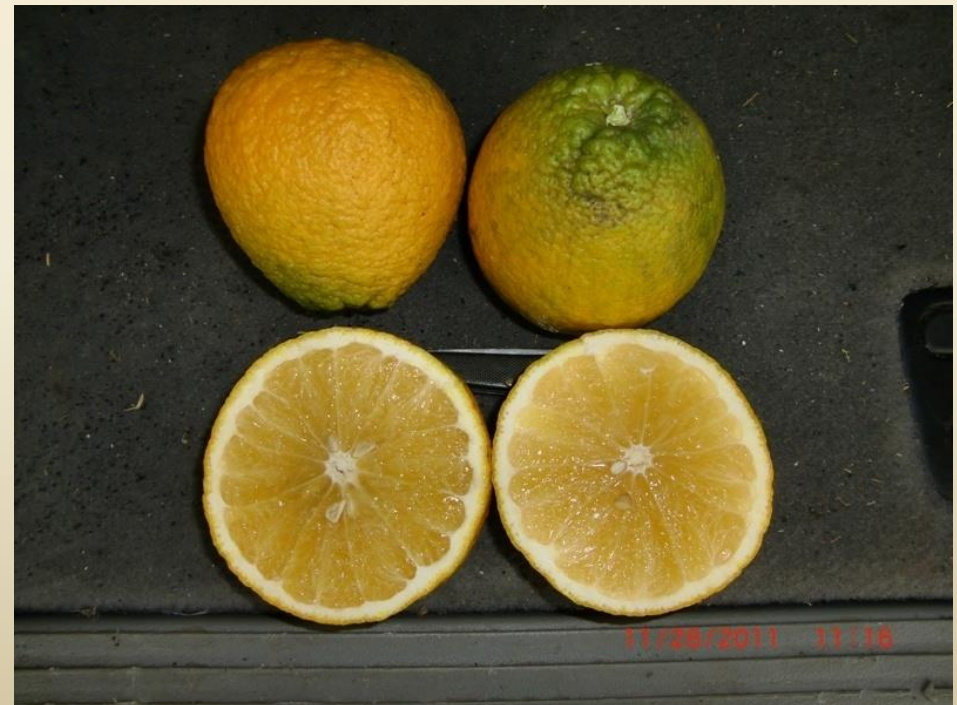
Apparent tolerance to HLB

*1/8 Poncirus*

Scored highly in sweet orange  
juice trial at USHRL

Used in many crosses

Hybrids starting to fruit!





SunDragon  
and Hamlin  
in replicated  
trial exposed  
to HLB at  
planting





# SunDragon progeny selections-2018



# SunDragon sibs- new selection



**USDA/ARS  
Ft. Pierce, FL**

Just selected from original seedling trees. 16 Brix, >1% acid, no drying, sweet orange flavor on June 1 of year following bloom.

This underscores the potential that is being unlocked, and emphasizes the value of discussing hybrids in OJ standards

## Greg McCollum-leads trials of new selections

- Has planted trees with numerous growers
- Replicated trials of best sweet-orange like hybrids and mandarin hybrids planted in 9 locations
- All replicated trials include standards such as Valencia
- Some include best new UF selections
- Data being collected on cropping growth and health

# FF 1-22-79, irradiated FF 1-42-65 Fortune x Encore



- Probably our best un-released tangerine
- Good external & internal color
- Not a bad pluggger
- Slightly pebbly skin usually come off in large chunks with little chipping
- Segment separation is usually good with little leakage
- Very rich flavor
- Ripening is usually around Christmas
- Fruit hold on the tree well into the new year
- Remarkably- its sib 1-42-70 is also one of most HLB-tolerant so far in trial!



**Ftp-4-13-31\***



**Ftp-4-13-7\***



**Ftp-6-13-39\***



**Low seeded selections of Irradiated FF-5-51-2 (Clementine x Orlando)**

- Seedy original hybrid growing many places and appears to have useful HLB-tolerance, with no evidence of HLB-affected fruit
- Good midseason tangerine (late Nov early Dec)
- Easy peeling, rich flavor, segments dry when separated. Dancy+ size.
- Appears to require cross pollination
- Trialing all 3 selections in case one has problems
- May release parent 2019

# Aerial view of 5-51-2 surrounded by Early Pride



**HLB-tolerance in some but not all mandarin types.**

**FF-1-35-21\***



**Ftp-6-1-41\***

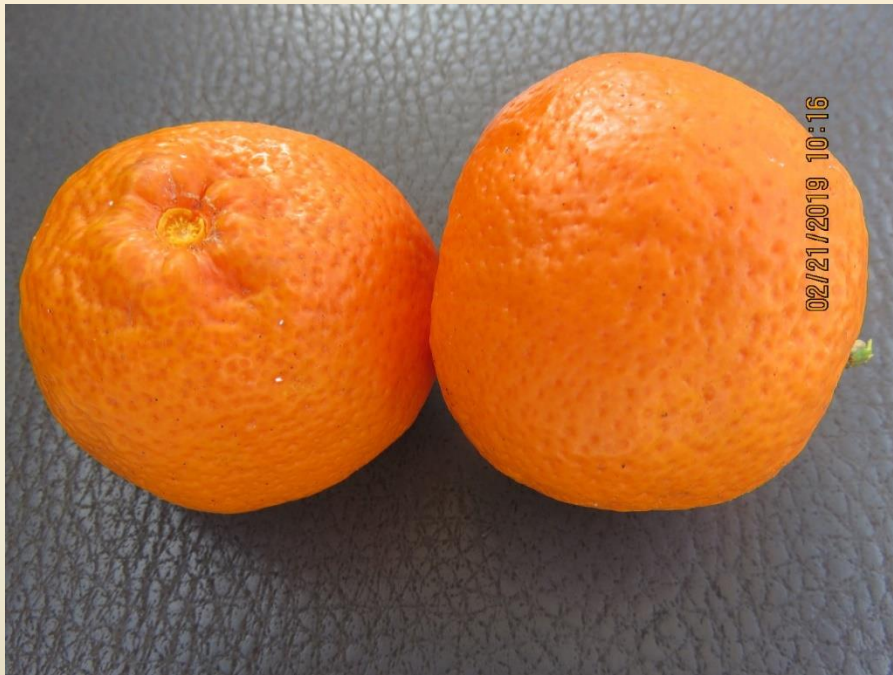


**FF-1-35-81(earliest)**

## **Mandarin hybrids (Fallglo x Kishu)**

- ~50% of mandarins with Kishu pollen-parent are seedless.
- These 3 best selections vary somewhat in size, ripening time (generally as early as October) and overall quality
- Hold acid surprisingly well and maintain on tree
- Easy peelers with little juice release
- Widely being tested with growers to verify quality etc. Smaller than Dancy
- Appear to have useful tolerance to HLB
- All are completely seedless.

New selection FF-1-88-82. Kishu hybrid with zippy acidity in April and no drying. Great pollen parent, possible niche fruit





Genetic seedlessness from Kishu transmitted to 50% of progeny in largely mandarin background.

First sweet-orange-like hybrid from Kishu



Many more new hybrids yet to flower.

Low seededness great for fresh fruit, but also desirable for processing since seeds can contribute to bitterness.

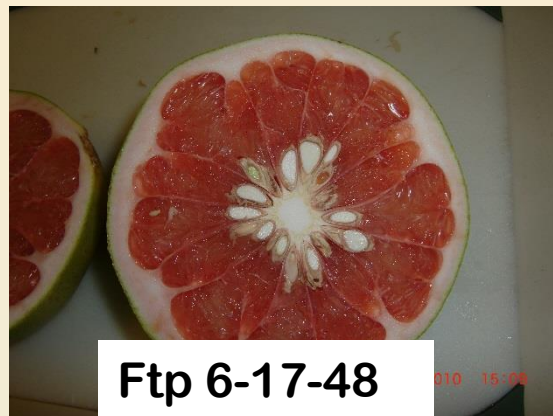


**FF1-83-179**

Late ripening pummelo hybrid with thin skin. It has exceptionally firm internal texture with small juice vesicles and deep pink color. Has mild taste and holds its color well.

## Irradiated GF-Like from Breeding Program

Complex hybrid containing pummelo, orange, tangelo, and grapefruit. Deep red interior color, pronounced skin blush.



**Ftp 6-17-48**

Late ripening pummelo hybrid with thin skin. Firm internal texture with small juice vesicles and deep pink color. Has mild taste and holds its color well.



**Ftp 6-16-172**

Early ripening pummelo hybrid with relatively thin skin and deep red color. Very mild, low acid taste with slight bitterness.



**Ftp 6-17-16**

# New grapefruit-like selections with Poncirus in pedigree, great health in single tree and no off-taste



Flame is pollen parent, very GF-like  
Ftp-6-59-158



Pummelo is pollen parent, some seed parent, GF-like in juiciness and small vesicles. Slight tonic  
Ftp-6-58-165

Sent to DPI: will be irradiated to knock out seeds when clean

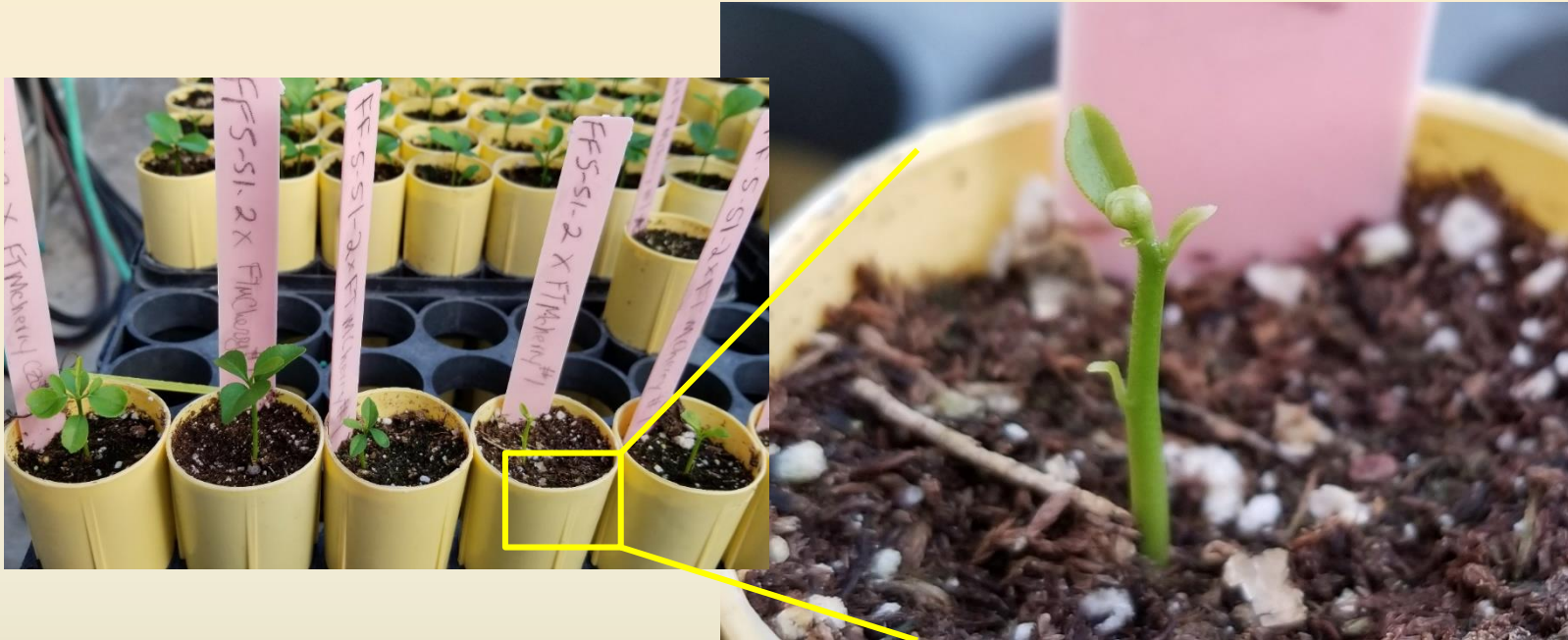
# FT that works for citrus breeding?

- Have shown that pollen germinates
- Have made crosses with FT-Mcherry pollen to introgress into priority hybrids
- Are combining with CRISPR to document ability to facilitate production of genome-edited citrus with no transgene in subsequent generations



**Collaboration  
Stover with T.  
McNellis and G.  
Moore**

# Hybridized 5-51-2 x FT-Mcherry Carrizo 5-13-2019



It works! Opens up vast diversity of citrus gene pool.  
Will permit 100 years of citrus breeding in 15-18  
years with final product not transgenic

# HLB-Tolerant Hybrids: update & potential for supplementing Florida OJ production?

A collaborative effort of members of the Florida  
citrus industry and research community

Ed Stover, Fred Gmitter, Liz Baldwin, Jude Grosser,  
Jinhe Bai, Yu Wang, Peter Chaires, Juan Carlos  
Motamayor, Kristen Carlson, Albert Wu



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-Ashley Witkowski -Leslie Benyon-Scott Ciliento -Shelby Durden -Debbie Flinn  
-Jonathan Giandalone -Amber Holland -Scott Hyndman -Phillip Matonti -Ivana Meservy  
-David Peabody -Ken Savage -Matthew Sewell -Ric Stange -Chelsea Veith - Patrick  
Zagorski

Some of the  
folks who do  
the real work

