# Citrus Scion & Rootstock Development for an HLB-Endemic Florida: The Way Forward

UF UNIVERSITY of FLORIDA
IFAS
Citrus Research and Education Center

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# A relevant quote from a world renowned biologist:

"Scientific research is thereby seldom straightforward. It rarely takes major leaps straight to the top. It moves obliquely, pressing forward at angles, reformulating, twisting, filling the subject out, waiting, looking around, describing parts more exactly, describing causal lineages more firmly, then, like a crack in a cave wall, a guiding beam of light comes through". .....Edward O. Wilson

- **Development of rootstocks that can impart HLB tolerance or resistance to grafted scions.**
- **Breeding of HLB tolerant or resistant processing sweet oranges and orange-like hybrids.**
- **Screening of the UF-CREC germplasm collection to identify and validate HLB tolerant or resistant selections**
- **Advanced field trials, release and commercialization of promising HLB tolerant/resistant scion and rootstock cultivars.**

# Project 15-010 Objectives

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- **Overcome the devastation of HLB**

- **Develop new, or recapture old, markets**
  - **Sweet oranges for the juice business**
  - **Mandarin hybrids**
  - **Grapefruit and grapefruit like hybrids**
  - **Acid fruit, e.g. lemons**

**Citrus breeding is a continuum, and requires a delicate and common sense balance between short/medium-term and long-term objectives**

# Our Priorities

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- First somatic hybrids in citrus
- First to exploit somaclonal variation for sweet orange
- First HLB-tolerant citrus cultivar ‘LB8-9’ Sugar Belle®
- First cybrid citrus cultivar: N2-28 Summer Gold grapefruit
- First triploid scion cultivar fathered by a somatic hybrid: C4-15-19
- OLL series, UF 914, EV1&2, Bingo, Marathon, Vernia, Valquarius, Valencia B9-65, 36+ Hamlin
- UFR Rootstock Series
- UF-914 grapefruit hybrid – low furanocoumarins, no drug interactions

# Our Track Record

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- First to develop genetic engineering techniques for citrus
- First to publish on phloem-specific promoters in citrus
- First to publish on long-term transgenic field tolerance in citrus
- First to demonstrate successful graft transmission of early flowering (FT) from transgenic rootstock to juvenile scions
- First molecular marker systems for genetic mapping
- First publicly available citrus genome sequences

# Our Track Record

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# BETTER ORANGES MAKE BETTER JUICE!

Improved Processing Sweet Oranges can significantly improve our NFC product!  Better flavor and color makes the product more attractive in the store, and will certainly have purchasers coming back for more! This will facilitate marketing and build a larger consumer-base.

Left: juice from OLL-8:

Right: Florida NFC purchased at Publix

- Current portfolio of Hamlin, Midsweet, and Valencia; is that where we want the future OJ business to be?
- New midseason options include Valquarius, Vernia, and an earlier maturing LS Midsweet
- Later season, higher quality options include improved clones of Valencia and some of the OLL series
- Early season options, not only high colored Hamlin, but now the groundbreaking ‘Florida EV 1’ and ‘Florida EV 2’
- Improved OLL-20 and Vernia C2-2-1 on the way

# New Sweet Oranges

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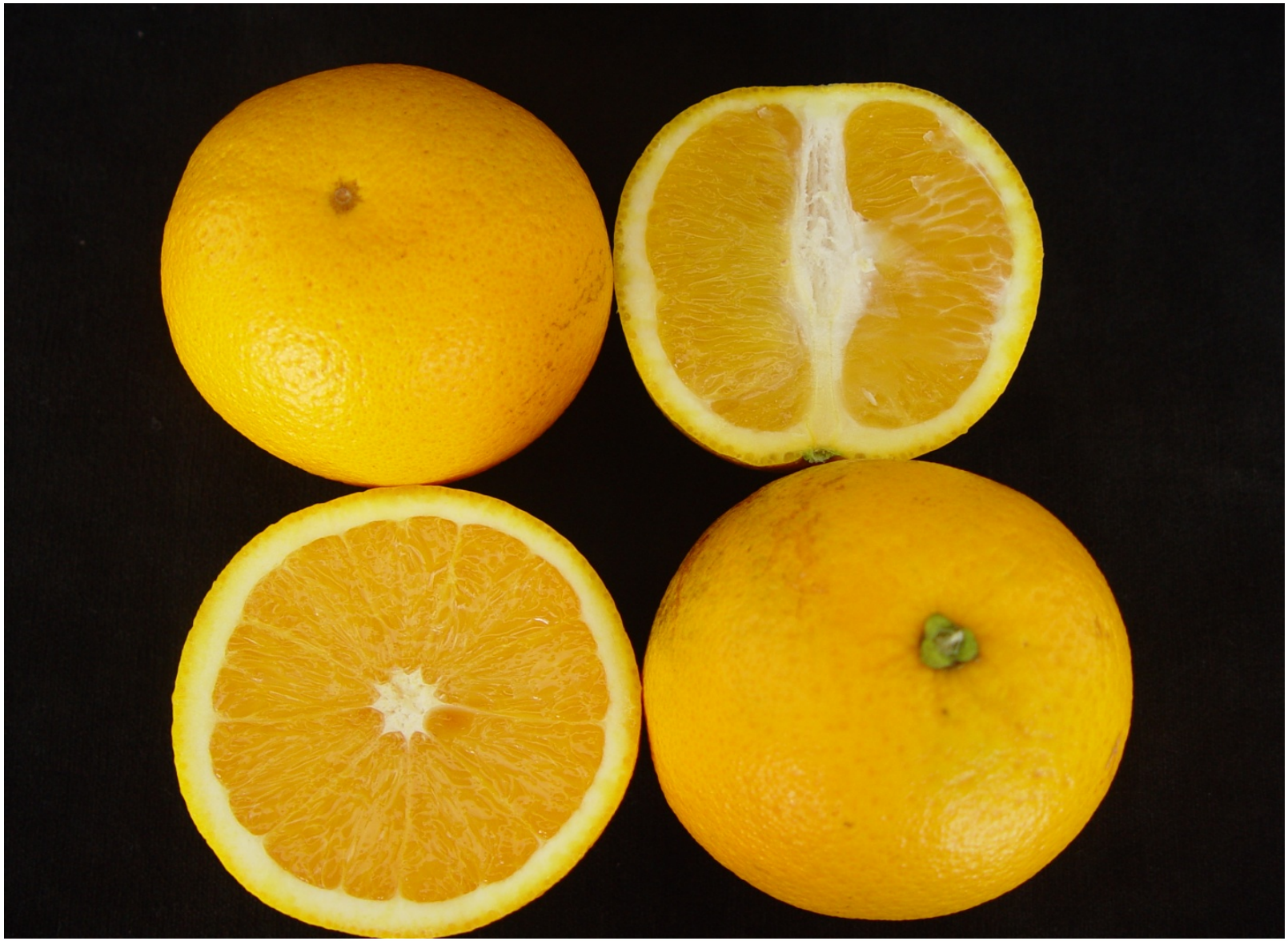

# Valquarius™

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7-year old reset of SF14W62 on rough lemon, showing yield potential.

**B9-65 Valencia for processing**
**Proposed name: 'ValAries' sweet orange**
**- A high yield, high solids selection with typical Valencia maturity, best of 30 selections in trial at Conserve II. Approved for release by IFAS Cultivar Release Committee**

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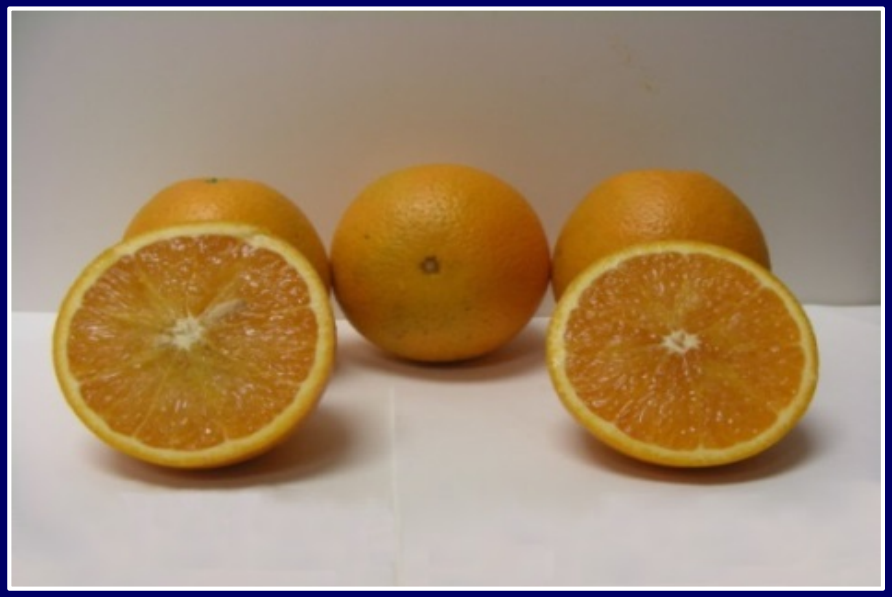
# ORANGES

**'OLL-8'**

- Key attributes: Excellent color and quality, extends harvest window of 'Valencia' quality juice
- Produces round oranges with internal and external color similar to 'Rhode Red Valencia'
- Holds on the tree exceptionally well, and maintains quality into the summer
- Trees appear to yield better than standard 'Valencia'
- High juice content and good pounds solids
- Peels easier than a standard 'Valencia'
- With its added color, could also be a valuable addition to the Florida fresh market portfolio
- Most precocious bearing clone among the OLL somaclones



**'OLL-4'**

- Key attributes: excellent color and quality, extends harvest window of 'Valencia' quality juice; also believed to be higher yielding than 'Valencia'
- Produces fruit with excellent internal and external quality with exceptional juice color scores, juice content and soluble solids
- Holds on the tree exceptionally well
- Maintains quality into the summer; however, it matured earlier, and with better ratios than 'Valencia' in 2014
- Has been the highest yielding tree among the OLL somaclones

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**Hamlin Somaclone N13-32 -** a new and distinct early season clone of Hamlin sweet orange improved juice color and typical or better soluble solids for processing.

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# EV 1 and EV 2

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Table 3. Juice data from 6-year old trees on rough lemon rootstock – Alligator Grove, St. Cloud, FL. Pilot-Plant Data from samples run on December 10, 2014.

| Variety | Wt. Sample | Wt. Juice | Lbs. Juice Per Box | Acid | Total Brix | Ratio | Fruit Ct | Lbs. Solids | Lbs. Solids Per Box | Juide Color |
|---|---|---|---|---|---|---|---|---|---|---|
| Vernia | 26.83 | 16.07 | 53.906 | 0.87 | 11.04 | 12.69 | 78 | 5.9512 | 5.95 | 35.3 |
| B7-70 | 26.94 | 15.24 | 50.913 | 0.71 | 11.30 | 15.92 | 61 | 5.7532 | 5.75 | 36 |
| Hamlin | 25.36 | 14.91 | 52.914 | 0.94 | 11.17 | 11.88 | 64 | 5.9105 | 5.91 | 34.5 |
| Valuarius | 25.69 | 14.48 | 50.728 | 0.84 | 9.87 | 11.75 | 55 | 5.0069 | 5.01 | 35.7 |
| SF14W-65 | 26.75 | 14.95 | 50.299 | 0.67 | 11.06 | 16.51 | 63 | 5.5631 | 5.56 | 36 |
| TI-19 | 28.14 | 16.71 | 53.443 | 0.98 | 9.53 | 9.72 | 58 | 5.0931 | 5.09 | 35.4 |

**EV-1 and EV-2 Early Valencias generally reach 15 ratio by Thanksgiving!**

# Citrus Budwood Annual Report 2017-2018

| SWEET ORANGES | | PROPAGATIONS | % of Type |
|---|---|---|---|
| Early | Hamlin 1-4-1 | 355,505 | 92.12 |
| | Hamlin 8-1-4 | 13,693 | 3.55 |
| | Hamlin 8-1-5 | 9,553 | 2.48 |
| | Ambersweet US 10-5-65 | 3,877 | 1.00 |
| | Parson Brown F-56-2 | 1,431 | <1 |
| | Other Early | 1,858 | |
| | Totals Early Season | 385,917 | |
| Navel | Cara Cara Navel CGIP-104 | 11,353 | 41.73 |
| | Glen Navel F-56-11 | 8,164 | 30.01 |
| | Summerfield Navel DPI-70-4-9 | 6,700 | 24.63 |
| | Wash Navel F-60-19 | 475 | 1.75 |
| | Wash Navel F-60-18 | 300 | 1.10 |
| | M-7 Early Navel CGIP-194 | 151 | <1 |
| | Other Navels | 60 | |
| | Totals Navel | 27,203 | |
| Midseason | Vernia UF 35-15 | 483,037 | 82.8 |
| | Florida EV1 UF B7-70 | 49,634 | 8.51 |
| | Florida EV2 UF SF14W-65 | 33,254 | 5.70 |
| | Valquarius LT UF SF14W-62 | 12,067 | 2.07 |
| | Midsweet US 6-9 | 3,274 | <1 |
| | Other Midseason | 1,861 | |
| | Totals Midseason | 583,127 | |
| Blood | Sanguinelli B/O US 10-5-17 | 3,386 | 82.9 |
| | Moro B/O 3-3-11 | 502 | 12.29 |
| | Budd B/O DPI-82 | 197 | 4.82 |
| | Total B/O | 4,085 | |
| Late | Valencia SPB-1-14-19 | 1,317,259 | 71.96 |
| | Sweet Orange UF OLL8 | 161,707 | 8.83 |
| | Valencia SPB-1-14-31 | 136,281 | 7.44 |
| | Valencia F-55-4 | 122,199 | 6.68 |
| | Sweet Orange UF OLL4 | 63,886 | 3.49 |
| | Valencia UF B9-65 | 18,145 | <1 |
| | Other Late Season | 11,165 | |
| | Totals Late Season | 1,830,642 | |
| | Total Sweet Oranges | 2,830,974 | |

# New sweet oranges available through PTP – 2018 – for testing via MTA

T1-62 (DPI-435-1-62) exceptional quality Valencia, very high solids (U&H Trial)

N7-2 (DPI 435-7-2) high solids, high yield Valencia, makes smaller trees (scion influence) (OrangeCo.)

N9-12 (DPI 435-0063) high solids, high yield Valencia (U&H)

T1-56 (DPI 435-0062) high solids, high yield Valencia (U&H)

T2-21 ( DPI-435-221) seedless Valencia clone, similar to N7-3 (CREC)

N10-13 (DPI 435-10-13) precocious bearing high solids, high yield Valencia (OrangeCo.)

N7-10 (DPI-435-7-10) high solids, high yield Valencia (OrangeCo.)

B3-42 (DPI-435-B3-42) high solids, high yield, Rhode Red Valencia (OrangeCo.)

BHG2-68 (DPI-435-0111) high solids, potentially enhanced HLB tolerance (Picos)

C1-41-B (DPI-435-0118) high solids, Rhode Red Valencia (cybrid), slightly better HLB tolerance (Lee)

OLL#20 (DPI-435-20) high solids, Orie Lee Late, superior juice flavor profile from HLB trees (Lee)

OLL#23 (DPI-435-0119) high yield, high solids Orie Lee Late (Lee)

OLL#10 (DPI-435-0066) high yield, high solids Orie Lee Late (Orie's favorite) (Lee)

OLL#6 (DPI-435-0037) high yield, high solids Orie Lee Late (Lee)

OLL#7 (DPI-435-0038) high yield, high solids Orie Lee Late (Lee)

Vernia C2-1-10 (DPI-435-110) slightly earlier Vernia (CREC)

Vernia C2-2-1 (DPI-435-C2-2-1), putatively more HLB tolerant Vernia (targeted 2020 release) (CREC)

**Combination of good scion genetics, good rootstocks genetics and evolving nutrition (McKenna nitrate program): OLL-8 sweet orange/UFR-4 rootstock, 4 year old trees – Working!**

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*
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# 2016-2019 Entries into the DPI Parent Tree Program

**Oranges and Orange-like hybrids**

1. **OLL-20IR #54:** low-seeded OLL-20 from budwood irradiation
2. **OLL-20IR #46:** low-seeded OLL-20 from budwood irradiation
3. **7-9-35:** Late maturing true sweet orange, similar to Valencia, HLB tolerant
4. **RBA-22-29**: HLB-tolerant sweet orange, irradiated Valencia budwood,
5. **C2-1-5:** triploid seedless Hamlin hybrid, early color and solids
6. **C4-14-53:** triploid seedless Succari hybrid, late maturing, high color and solids, peelable
7. **3-3-52**:Diploid sweet orange-like mandarin hybrid selected for HLB tolerance, mid-season
8. **6-2-55:**Triploid mandarin/sweet orange hybrid, selected for HLB tolerance, late maturing

# 2016-2019 Entries into the DPI Parent Tree Program

## Pummelo/Grapefruit

1. **C4-4-8**: canker tolerant grapefruit-like pink pummelo
2. **KW-1-50**: canker tolerant, low seeded red-fleshed pummelette
3. **N40-16-12-7**: sweet flavored dark red pummelo
4. **5-1-99-5-LS**: nearly seedless 5-1-99-5 dark red pummelo from budwood irradiation
5. **B3R1T43**: Canker and HLB tolerant true pummelo, vigorous
6. **3-1-21:** True pink/red HLB and canker tolerant pummelo
7. **3-1-22**: True pink/red HLB and canker tolerant pummelo

# 2016-2019 Entries into the DPI Parent Tree Program

**Mandarins**

1. **18A-1-25:** Seedless triploid mandarin hybrid.
2. **18A-8-48:** Seedless triploid mandarin hybrid.
3. **C4-15-50**: Seedless triploid mandarin hybrid.
4. **McTeer Murcott**: Low-seeded Murcott, produced via budwood irradiation
5. **18A-2-31**: Seedless triploid mandarin hybrid.
6. **Cybrid Dancy KW-5-7**: Cybrid clone of Dancy tangerine, Alternaria tolerant
7. **C4-15-3:** Seedless triploid mandarin hybrid
8. **C4-5-50:** Seedless triploid mandarin hybrid
9. **18A-4-46 triploid mandarin**: Seedless triploid mandarin hybrid.
10. **C7-12-14:** Seedless triploid mandarin hybrid.
11. **C4-7-29**: Seedless triploid mandarin hybrid.
12. **C1-7-30**: Seedless triploid mandarin hybrid
13. **C1-1-1**: Seedless triploid mandarin hybrid.
14. **C1-8-34**: Seedless triploid mandarin hybrid.
15. **C4-16-23**: Seedless triploid mandarin hybrid.
16. **C4-11-45**: Seedless triploid mandarin hybrid.
17. **C4-10-42**: Seedless triploid mandarin hybrid.
18. **KE-7-39** triploid seedless mandarin

# 2016-2019 Entries into the DPI Parent Tree Program

**Mandarins (cont.)**

1. **C7-10-47** triploid seedless mandarin
2. **C4-14-1** triploid seedless mandarin
3. **C1-4-28** triploid seedless mandarin
4. **C7-12-18** triploid seedless mandarin
5. **C7-12-24** triploid seedless mandarin
6. **C2-3-26** triploid seedless mandarin
7. **KE-9-9:** Seedless triploid mandarin hybrid.
8. **18A-2-28:** Seedless triploid mandarin hybrid.
9. **18A-1-40:** Seedless triploid mandarin hybrid.
10. **UF 711**: Fast Track cultivar previously submitted to PTP, previous release incorrect
11. **VNB 36-43**:Seedless diploid mandarin hybrid, early maturity and easy to peel
12. **VNB 40-4:** Seedless diploid mandarin hybrid, early maturity and easy to peel
13. **7-8-87:** Diploid hybrid mandarin, seedless, easy to peel
14. **1723:** Early-mid season, easy peeling and seedless diploid mandarin
15. **1724:** Early-mid season, easy peeling and seedless diploid mandarin
16. **7-9-7:** Mid-late season, easy peeling and seedless diploid mandarin.
17. **1703:** Early maturing, seedless, and easy peeling diploid mandarin, great flavor
18. **1722:** Early maturing, seedless, and easy peeling diploid mandarin, great flavor

# 2016-2019 Entries into the DPI Parent Tree Program

**Acid Fruit hybrids**

1. **ST+LL x CE-Lemon-15:** Seedless triploid, ‘Key’ lime flavor & exceptional fragrance.
2. **ST+LL x CE-Lemon-72;** Seedless triploid, juicy lemon-limquat with limey flavor
3. **CE-D-5 (1-9-42)** high-oil, seedless lemon clone (from CCC project).
4. **Bea D-3 (1-8-59**) high-oil, low seeded lemon clone (from CCC project).
5. **C4-8-48**: seedless triploid with good lime flavor, HLB tolerant
6. **UF 2-3-33**: Lemon selected for high peel oil production
7. **UF 1-20-6:** Lemon selected for high peel oil production
8. **UF 1-8-57**: Lemon selected for high peel oil production

# 2016-2019 Entries into the DPI Parent Tree Program

**Breeding Parents**

1. **Nova+Osceola**: Somatic hybrid allotetraploid mandarin breeding parent for use in interploid crosses. Transmits exceptional color to progeny.

2. **Murcott+LB8-8:** Somatic hybrid allotetraploid mandarin breeding parent for use in interploid crosses. Transmits low acidity and excellent fruit quality. Good HLB tolerance.

3. **Page + [Clementine x Satsuma]:** Somatic hybrid allotetraploid breeding parent for use in interploid crosses. Transmits good color, zipperskin peel and good fruit size.

4. **Low-acid pummelo:** Same as Siamese Sweet, a useful breeding parent for grapefruit improvement; it is the seed parent of UCR cultivars Melogold and Oroblanco (Sweetie), and UF 914; 2017.

# 2016-2019 Entries into the DPI Parent Tree Program

**Rootstock Candidates**

1. **2247x6070-02-2:** tetrazyg, small trees, very high soluble solids; seedy
2. **2247x2075-02-26**: tetrazyg, good all around, seedy
3. **A+HBJL-1-OP-09-36**: Gauntlet selection, tetraploid sour type, high soluble
4. **A+Volk x Orange 19-11-8**: Gauntlet selection, complex tetraploid, seedy
5. **Milam + HBP x Orange 14-09-9**: Gauntlet selection, complex tetraploid, seedy
6. **Amblycarpa + HBJL-2:** tetraploid sour type, good at St. Helena
7. **Green 6 x Orange 14-09-32:** Gauntlet tetrazyg rootstock, high solids
8. **Milam+HBPxOrange14-09-10:** Gauntlet tetrazyg rootstock
9. **46x20-04-S15:** Sour orange-type diploid rootstock (HBPummelo x Cleo)
10. **46x20-04-6:** Sour orange-type diploid rootstock,(HBPummelo x Cleo)
11. **11-4-1**: Trifoliate rootstock hybrid

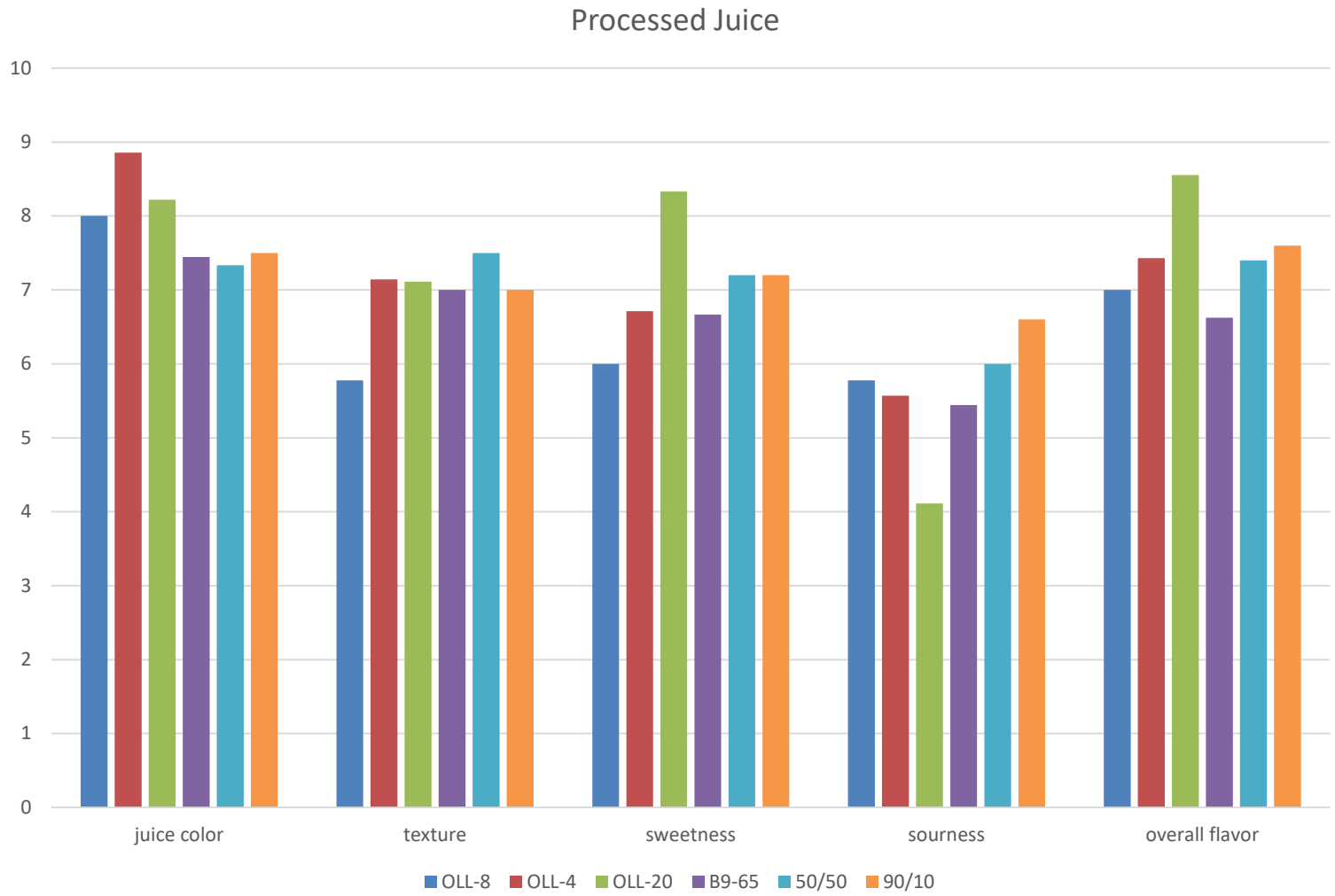


Figure 2. February 19 2019 Juice Display Results (subjective mean scores from display attendees; scale of 0-10 with 10=perfect score). 50/50 is a 1:1 blend of pasteurized Valquarius and LB8-9 Sugar Belle® juice; 90/10 a 9:1 blend of the same.

Original Vernia Somaclones/Swingle @ CREC (photo July 12, 2019). Vernia clone C2-2-1 through PTP and being prepared for release.

OLL Seedling-derived trees, Frank's Block 13E, Orie Lee Groves, St. Cloud, 5-year old trees grown with no psyllid control – 350 individual trees.

OLL (Orie Lee Late) Seedling-Derived Trees – Frank's Block 13E, Orie Lee Groves, St. Cloud. 5.5 year old trees grown with no psyllid control. Data from best trees out of 350 , fruit harvested mid-January, 2019.

| Row | three | 1ºBrix | Total Brix | Ratio | Acid | Juice Color | Lbs. Solids Per Box | Averege #seeds/fruit | Cal_ct | Diagnosis |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | T28 | 8.8 | 11.81 | 11.58 | 1.02 | 37.2 | 6.50 | 3.70 | 40.00 | No HLB Found |
| R2 | T26 | 7.6 | 10.73 | 11.06 | 0.97 | 37.1 | 5.54 | 3.80 | 30.10 | Questionable |
| R2 | T30 | 7.8 | 10.97 | 12.33 | 0.89 | 37.6 | 5.90 | 3.70 | 33.89 | No HLB Found |
| R2 | T35 | 8.0 | 10.56 | 12.88 | 0.82 | 37.8 | 5.42 | 4.50 | 31.79 | Questionable |
| R3 | T2 | 8.2 | 10.75 | 11.44 | 0.94 | 37.5 | 5.62 | 3.80 | 30.18 | Questionable |
| R3 | T12 | 7.4 | 9.87 | 11.22 | 0.88 | 36.8 | 4.98 | 4.50 | 31.16 | Questionable |
| R3 | T16 | 7.2 | 10.47 | 12.61 | 0.83 | 36.2 | 5.12 | 4.60 | 30.11 | Questionable |
| R3 | T18 | 8.2 | 10.89 | 11.59 | 0.94 | 37.0 | 5.74 | 3.20 | 31.28 | Questionable |
| R3 | T32 | 8.4 | 10.66 | 11.34 | 0.94 | 37.3 | 5.44 | 3.80 | 30.27 | Questionable |
| R3 | T34 | 8.6 | 10.67 | 12.13 | 0.88 | 37.5 | 5.48 | 4.40 | 30.36 | Questionable |
| R4 | T13 | 8.5 | 11.22 | 14.20 | 0.79 | 37.2 | 5.65 | 2.10 | 30.03 | Questionable |
| R5 | T4 | 8.5 | 10.65 | 10.54 | 1.01 | 38.1 | 5.62 | 4.50 | 30.12 | Questionable |
| R5 | T30 | 9.0 | 11.11 | 11.11 | 1.00 | 37.1 | 5.81 | 4.20 | 30.41 | Questionable |
| R6 | T4 | 8.5 | 11.18 | 10.75 | 1.04 | 36.8 | 5.67 | 3.20 | 30.51 | Questionable |
| R6 | T5 | 8.9 | 10.66 | 11.34 | 0.94 | 36.9 | 5.41 | 3.60 | 30.20 | Questionable |
| R6 | T6 | 8.5 | 10.74 | 10.53 | 1.02 | 37.0 | 5.46 | 3.60 | 33.89 | No HLB Found |
| R7 | T5 | 7.8 | 9.42 | 10.83 | 0.87 | 37.2 | 4.82 | 4.40 | 30.10 | Questionable |
| R7 | T6 | 7.8 | 10.15 | 10.91 | 0.93 | 37.4 | 5.25 | 4.10 | 30.31 | Questionable |
| R7 | T7 | 8.0 | 10.21 | 12.01 | 0.85 | 37.4 | 5.32 | 4.50 | 33.48 | No HLB Found |
| R7 | T12 | 8.3 | 9.55 | 11.65 | 0.82 | 37.0 | 5.07 | 5.60 | 30.70 | Questionable |
| R7 | T13 | 7.7 | 9.67 | 10.07 | 0.96 | 36.6 | 5.01 | 3.70 | 34.06 | No HLB Found |
| R7 | T17 | 8.4 | 10.35 | 12.47 | 0.83 | 37.4 | 5.58 | 5.00 | 36.00 | No HLB Found |
| R8 | T6 | 8.3 | 10.39 | 12.67 | 0.82 | 35.9 | 4.69 | 3.70 | 34.19 | No HLB Found |
| R8 | T7 | 8.2 | 10.51 | 12.82 | 0.82 | 32.4 | 4.07 | 2.80 | 31.04 | Questionable |
| R8 | T13 | 8.5 | 10.61 | 11.79 | 0.90 | 37.2 | 5.41 | 3.20 | 33.22 | No HLB Found |
| R8 | T14 | 9.2 | 11.20 | 13.83 | 0.81 | 36.3 | 5.49 | 2.30 | 30.26 | Questionable |
| R8 | T23 | 8.6 | 9.52 | 12.21 | 0.78 | 36.4 | 4.90 | 4.80 | 40.00 | No HLB Found |

| Row | three | 1ºBrix | Total Brix | Ratio | Acid | Juice Color | Lbs. Solids Per Box | Averege #seeds/fruit | Cal_ct | Diagnosis |
|---|---|---|---|---|---|---|---|---|---|---|
| R8 | T31 | 9.1 | 10.39 | 10.29 | 1.01 | 37.0 | 5.11 | 3.60 | 30.25 | Questionable |
| R9 | T12 | 7.8 | 9.95 | 11.06 | 0.90 | 37.0 | 5.13 | 3.90 | 30.39 | Questionable |
| R9 | T33 | 8.6 | 10.28 | 13.71 | 0.75 | 37.2 | 5.35 | 4.40 | 31.05 | Questionable |
| R10 | T3 | 8.6 | 10.34 | 11.62 | 0.89 | 37.1 | 5.57 | 4.70 | 31.39 | Questionable |
| R10 | T5 | 9.1 | 10.90 | 11.47 | 0.95 | 37.3 | 6.01 | 4.70 | 31.31 | Questionable |
| R10 | T6 | 9.3 | 10.77 | 11.71 | 0.92 | 37.6 | 5.88 | 5.50 | 32.54 | No HLB Found |
| R10 | T9 | 8.2 | 9.79 | 10.53 | 0.93 | 37.2 | 5.12 | 4.20 | 30.29 | Questionable |
| R10 | T11 | 8.7 | 9.93 | 10.79 | 0.92 | 37.1 | 5.32 | 5.50 | 31.43 | Questionable |
| R10 | T12 | 8.3 | 11.51 | 12.65 | 0.91 | 37.0 | 6.29 | 5.50 | 33.22 | No HLB Found |
| R10 | T13 | 9.3 | 11.29 | 12.27 | 0.92 | 37.5 | 6.05 | 4.20 | 30.10 | Questionable |
| R10 | T14 | 8.3 | 9.92 | 12.25 | 0.81 | 37.7 | 5.34 | 5.10 | 30.71 | Questionable |
| R10 | T15 | 8.7 | 9.38 | 11.73 | 0.80 | 37.6 | 4.90 | 3.60 | 36.00 | No HLB Found |
| R10 | T19 | 8.0 | 9.79 | 12.09 | 0.81 | 36.9 | 4.88 | 5.30 | 31.16 | Questionable |
| R10 | T20 | 8.9 | 11.33 | 11.33 | 1.00 | 37.2 | 5.99 | 4.90 | 31.13 | Questionable |
| R10 | T24 | 9.0 | 10.33 | 10.99 | 0.94 | 37.9 | 5.60 | 5.30 | 37.82 | No HLB Found |
| R10 | T28 | 8.5 | 10.41 | 12.39 | 0.84 | 36.9 | 5.43 | 4.10 | 30.97 | Questionable |
| R10 | T32 | 8.9 | 11.49 | 11.85 | 0.97 | 38.4 | 6.37 | 5.20 | 30.72 | Questionable |
| R7 | T32 | 9.4 | 11.70 | 11.25 | 1.04 | 38.7 | 6.20 | 4.3 | 33.09 | No HLB Found |
| R8 | T11 | 10.1 | 9.90 | 10.88 | 0.91 | 39.3 | 5.26 | 4.9 | 30.53 | Questionable |
| R8 | T30 | 9.6 | 11.17 | 11.17 | 1.00 | 38.0 | 5.87 | 5.5 | 40.00 | No HLB Found |
| R8 | T32 | 9.7 | 10.62 | 14.35 | 0.74 | 37.9 | 5.21 | 4.2 | 31.39 | Questionable |
| R8 | T34 | 10.5 | 10.92 | 12.13 | 0.90 | 38.7 | 5.44 | 3.9 | 30.14 | Questionable |
| R9 | T14 | 9.6 | 10.39 | 10.60 | 0.98 | 38.7 | 5.48 | 6.0 | 30.54 | Questionable |
| R10 | T17 | 9.4 | 10.00 | 11.63 | 0.86 | 38.2 | 5.14 | 4.3 | 32.28 | No HLB Found |
| R10 | T33 | 9.4 | 11.64 | 11.76 | 0.99 | 38.1 | 6.54 | 5.1 | 31.58 | Questionable |

Clas diagnostic data via Mike Irey @ Southern Gardens diagnostic lab.



*

# SERENDIPITY

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# Valencia Mutant

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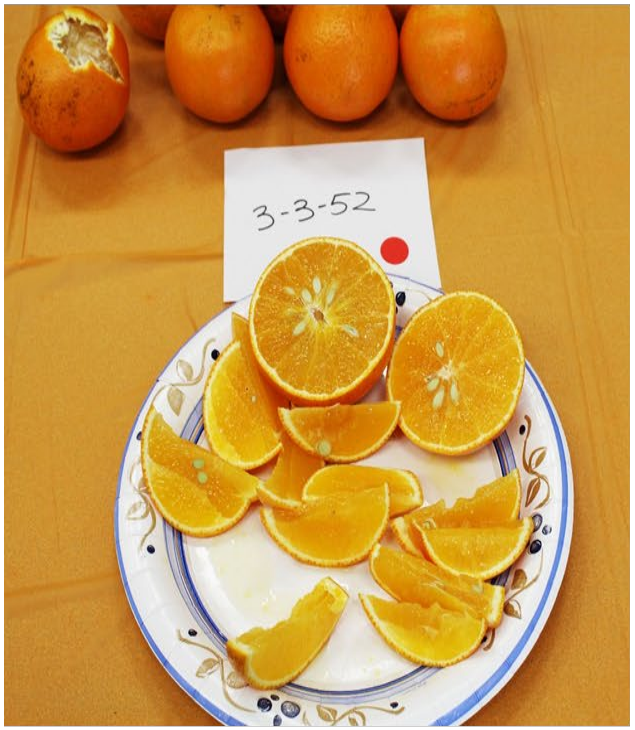
# An orange-like hybrid **3-3-52** appears tolerant and was ranked highest in flavor at the CREC Fruit Display Day in February 2016 and 2017




# Nursery “dirty house” summary

| Scion | No HLB Found | Total | % of No HLB |
|---|---|---|---|
| 18A-2-43 | 86 | 98 | 87.76 |
| **3-3-52** | 26 | 26 | 100.00 |
| 6-2-55 | 55 | 63 | 87.30 |
| 7-9-31 | 26 | 28 | 92.86 |
| C4-14-51 | 64 | 115 | 55.65 |
| C4-14-53 | 58 | 92 | 63.04 |
| C7-12-19 | 78 | 81 | 96.30 |
| 18A-2-31 | 52 | 90 | 57.78 |
| LB9-4 | 56 | 75 | 74.67 |
| OLL-DCS-3-36 | 45 | 45 | 100.00 |
| OLL-DCS-3-40 | 99 | 101 | 98.02 |
| RBA-21-36 | 44 | 47 | 93.62 |
| **RBA-22-29** | 68 | 68 | 100.00 |
| **Total** | **757** | **929** | |

*

# Candidates for FCPA-Industry-Wide Juice Enhancement Project – 2019 – UF-CREC

## Orange-like hybrids showing with processing potential showing HLB tolerance - Grosser

1. C2-1-5: Seedless triploid Hamlin hybrid, matures in Hamlin period, but with much better juice color and higher brix than Hamlin. November 2018 fruit display - juice favored over Hamlin and EV's. Cross: FallGlo x [Hamlin + Dancy]. Heavy cropping potential. Status: currently in PTP.

2. C4-16-12: Seedless triploid hybrid, matures in Hamlin period, but with much higher brix (up to 15), and slightly better juice color. 80-20% blend with C4-10-42 mandarin hybrid highly favored at December 2018 juice display. Cross: G96 trifoliate hybrid x [Succari + Murcott]. Status: through PTP, clean budwood available. Fruit splitting can be a problem on young trees.

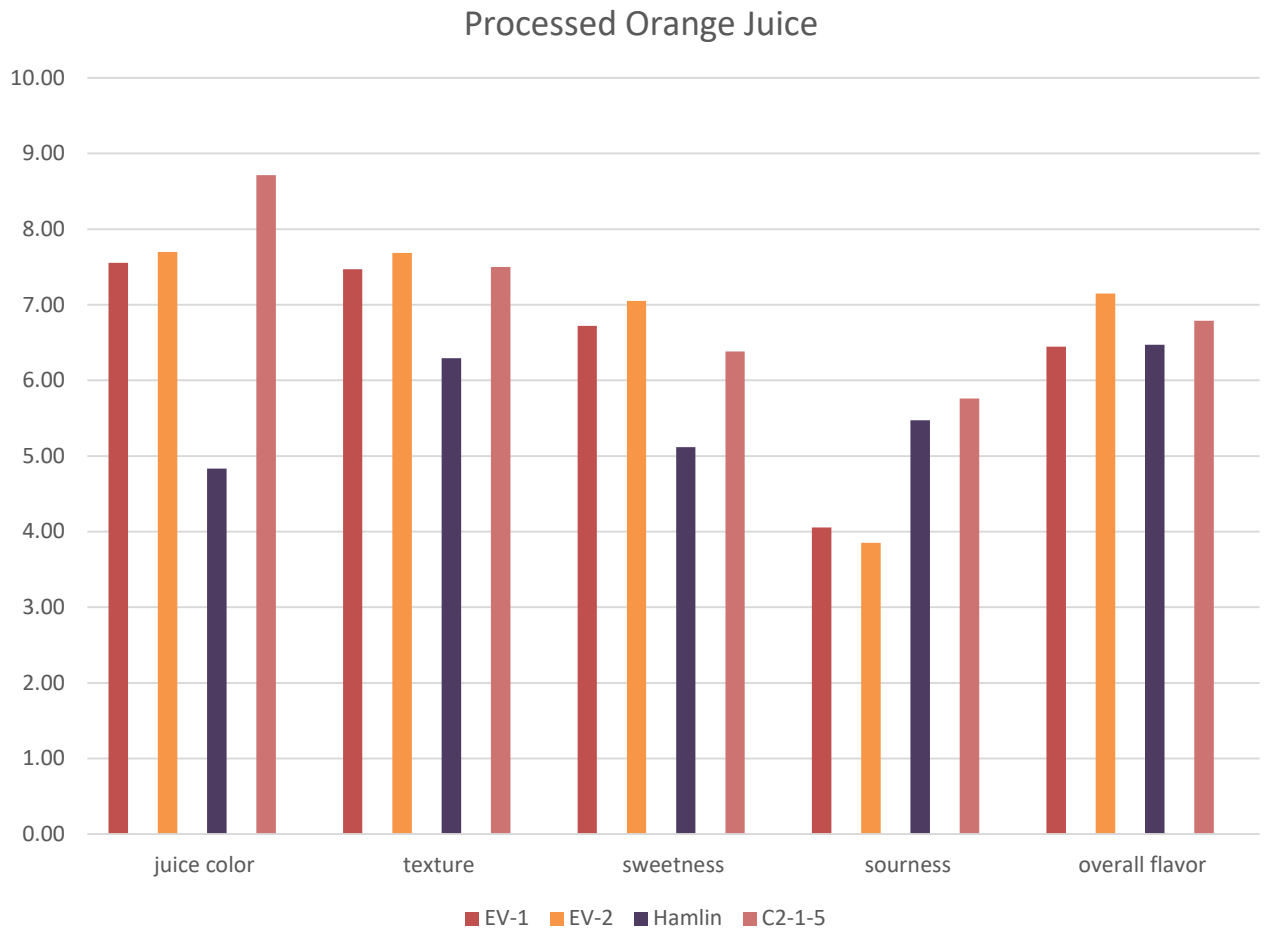



Figure 3. October 30, 2018 Juice Display Data (subjective mean scores from display attendees; scale of 0-10 with 10=perfect score): EV-1 & EV-2 are early-maturing Valencia clones; Hamlin is the standard early season cultivar; and C2-1-5 is a seedless triploid orange-like Hamlin hybrid that is only 1/3 sweet orange, showing good HLB tolerance thus far.

# LB8-9 (Sugar Belle®)

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# Sugar Belle® near Vero Beach, HLB+ >8 years !

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# Sugar Belle® in SW Florida, 4 years old

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New hybrids from quality parents showing HLB tolerance that exceeds Sugar Belle!

Can Sugar Belle transmit it's high level HLB-tolerance to progeny? YES! Above see two seedless triploid hybrids of Sugar Belle x [Nova+Osceola] with HLB tolerance as good or better than Sugar Belle.

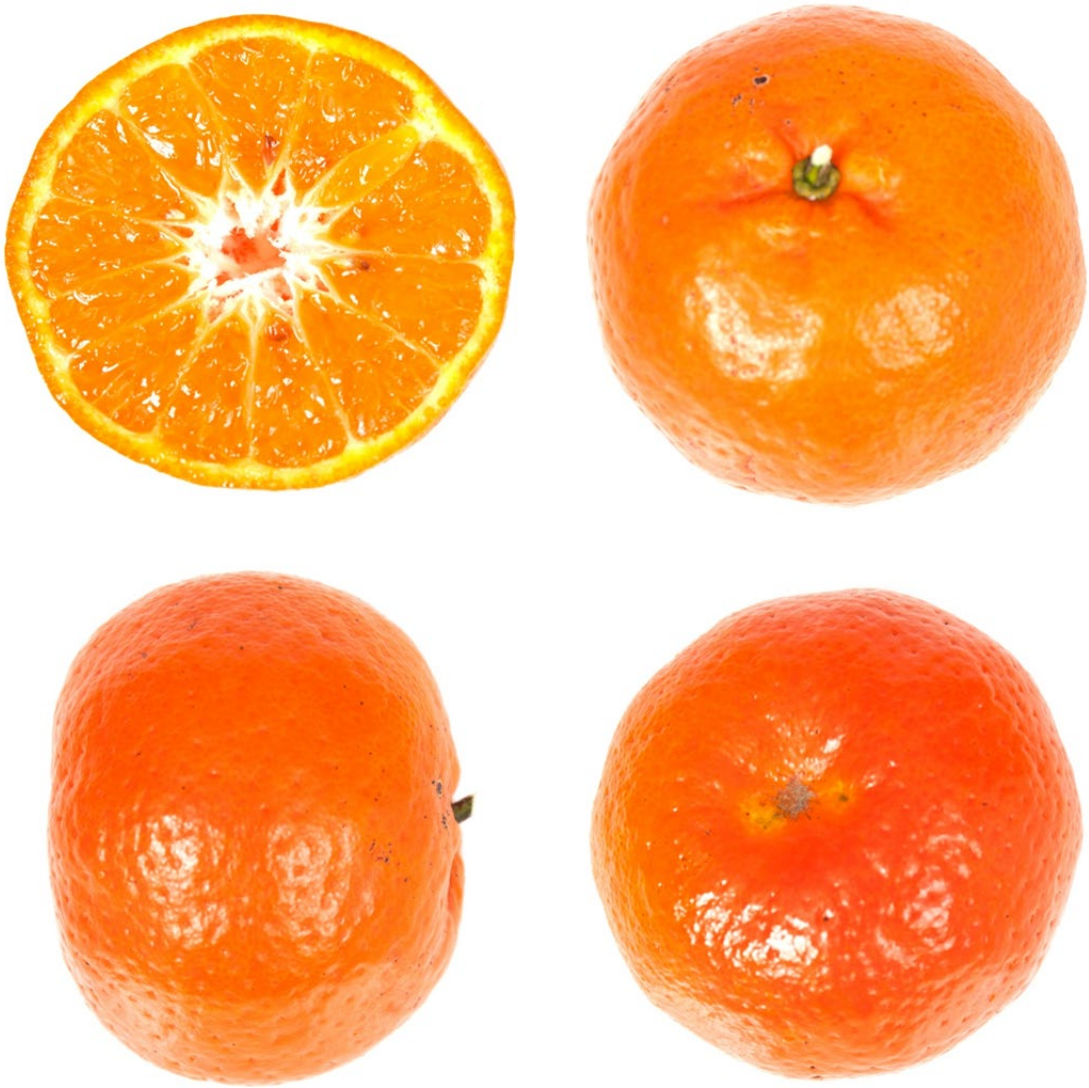
*

# 411 Mandarin Hybrid – Resurgence against HLB!

411 mandarin hybrid showing a resurgence against HLB on multiple rootstocks. HLB+ tree on WGFT+50-7 rootstock shown on right dug up from lost Haines City trial and moved to CREC 4 years ago, among several showing a remarkable recovery and productivity!  An absolutely delicious piece of fruit!

# UF 950

- EZ to peel, seedless
- Clementine size
- Convenient to eat
- Crisp texture
- Better color and flavor than Clementine
- December maturity
- Alternaria resistant
- HLB tolerant
- Moved into commercial plantings



# ‘BINGO’

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# ‘Bingo’ on 4/4/16

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# UF Mandarin Selection 1420

# Suggested name: ‘Marathon’

# A FAST-TRACK Release

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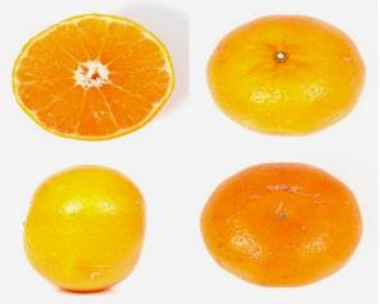
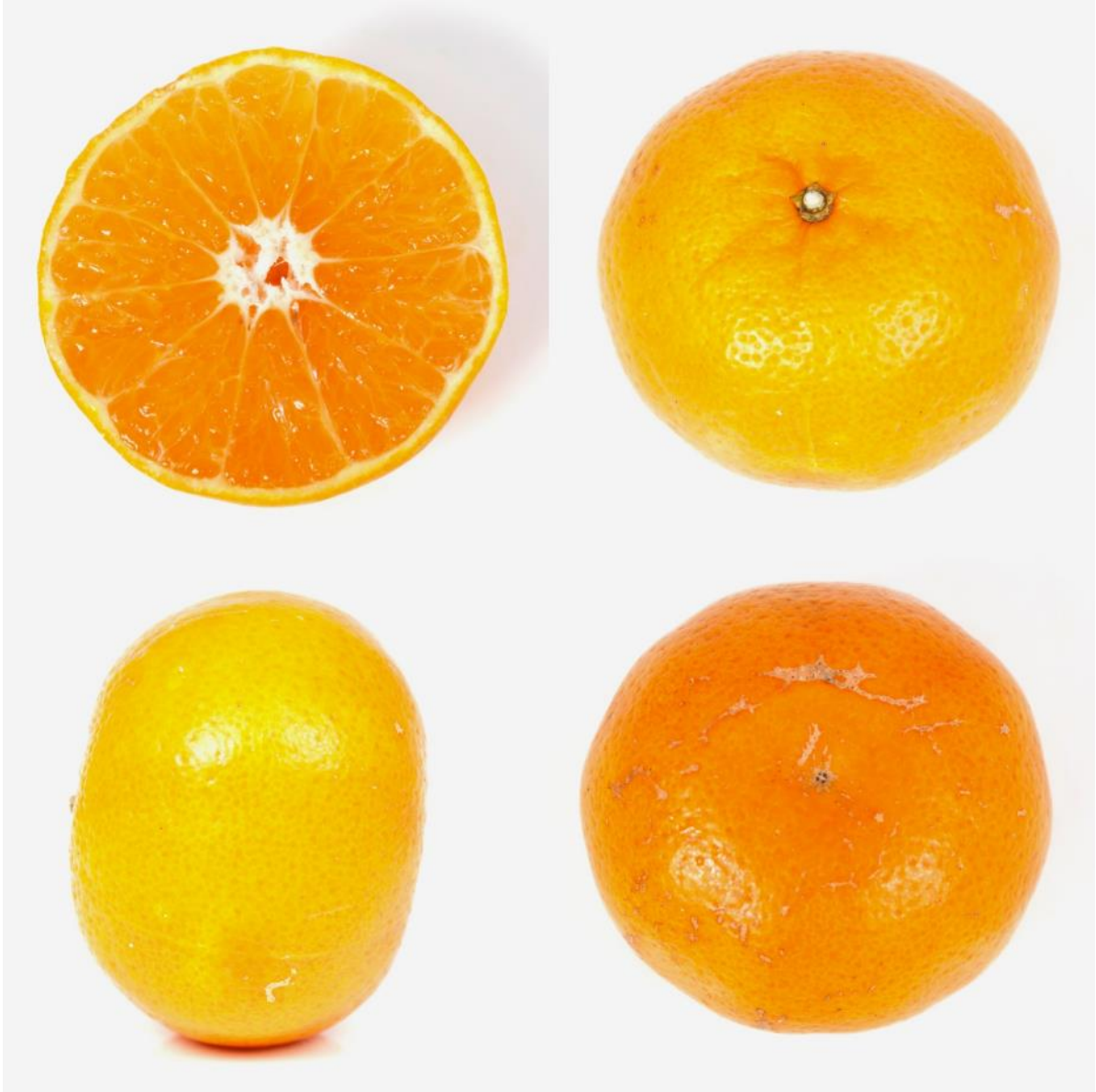
Fred G. Gmitter Jr.
University of Florida



…on behalf of the Team!



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# ‘Marathon’

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- **Brix: 12.5 Acid: 0.89 Ratio: 14.04 19 August 2015**
- **Brix: 13.0 Acid: 0.59 Ratio: 22.03 25 September 2015**
- **Brix: 14.0 Acid: 0.69 Ratio: 20.28 29 October 2015**
- **Brix: 17.4 Acid: 0.62 Ratio: 28.06 17 December 2015**
- **Fruit remained in sound condition until early January**
- **No clipping required**

# 1420: Long Maturity Window

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# UF 914


WESTCOTT
1cm 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

# N2-28 Summer Gold Grapefruit

**Table 1. Comparison between summer N2-28 'Summer Gold Grapefruit' and controls 'Ruby Red' and 'Pink Marsh" for the Brix, color and titrable acidity value (average of 20 fruit per selection, test conducted July, 2013).**

| | Brix° | Color | Titrable Acidity (ml) |
|---|---|---|---|
| Summer Gold N2-28 | 11.6 | 34 | 0.98 |
| 'Ruby Red' grapefruit | 9.4 | 34.5 | 0.85 |
| 'Pink Marsh' grapefruit | 8.2 | 34.3 | 1.2 |

- Cybrid with 'Dancy' cytoplasm
- Sweeter than Ruby Grapefruit
- Harvest from December to August!
- No granulation or seed germination

- **Several hundred hybrid families produced over the past 30 years**
- **Great genetic diversity**
- **Nearly 9000 trees have been evaluated for HLB severity**
- **~4.3% superior in response to *C*Las**
- **Next steps: genotyping and association**

*

# Toward Genomic Selection

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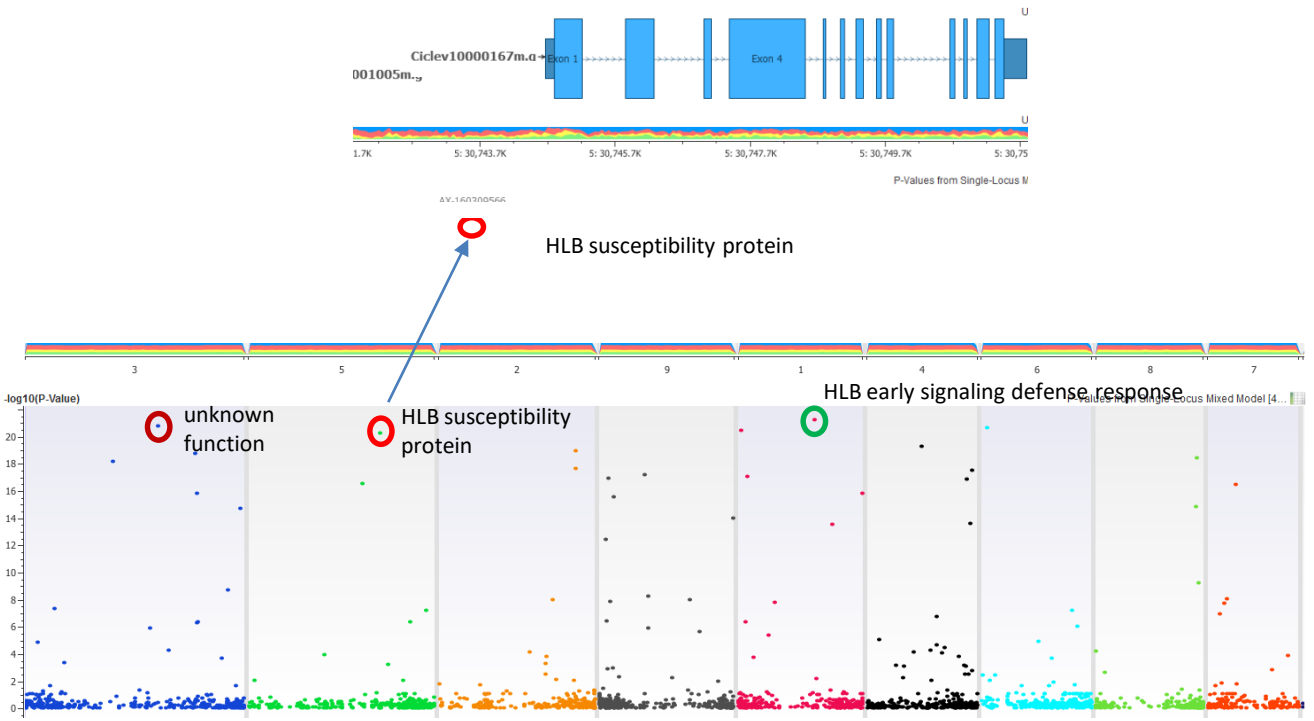
# “Manhattan Plot” showing SNPs responsible for HLB on citrus nine chromosomes

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**GREC-BALM Rescue:** The UF/CREC Citrus Improvement Team recently lost 50 acres of program citrus germplasm due to the water crisis at the GREC. The entire 50 acres was indexed for HLB tolerance, and 2200 tolerant selections were Identified. We have successfully rescued about 1600 of these, to be planted soon.

# Now to Rootstocks:

The UF/CREC Citrus Improvement Team has worked very hard to establish a common sense delicate BALANCE between providing viable/profitable rootstock options for the short-medium term, and developing the HOMERUN rootstock(s) that will be the ANSWER for the future, regardless of the scion.

# Citrus Budwood Annual Report 2017-2018, Rootstocks

| 2018 | | # budded | 2017 | 2016 |
|---|---|---|---|---|
| 1 | Swingle | 683,378 | Swingle | Kuharske |
| 2 | US-942 | 661,003 | US-942 | X-639 |
| 3 | Kuharske | 504,639 | X-639 | S/O |
| 4 | Sour Orange | 418,407 | Kuharske | US-897 |
| 5 | X-639 | 349,046 | Sour Orange | SWG |
| 6 | US-897 | 243,781 | US-802 | US-942 |
| 7 | US-802 | 169,465 | US-897 | US-802 |
| 8 | Own Root | 163,966 | UFR-04 | US-812 |
| 9 | US-812 | 146,410 | US-812 | Cleopatra |
| 10 | Volkamer | 119,276 | C-35 | UFR-04 |
| 11 | C-35 | 86,181 | Cleopatra | Volkamer |
| 12 | UFR-04 | 71,231 | Volkamer | Kinkoji |
| 13 | P Trifoliate | 53,935 | UFR-03 | UFR-03 |
| 14 | Rough Lemon | 33,909 | C-22 | Carrizo |
| 15 | UFR-03 | 32,853 | Carizzo | Rough Lemon |
| 16 | UFR-06 | 28,617 | Rough Lemon | Research |
| 17 | Cleopatra | 21,760 | UFR-17 | UFR-02 |
| 18 | C-22 | 19,361 | Kinkoji | UFR-17 |
| 19 | US-896 | 18,205 | UFR-01 | UFR-16 |
| 20 | UFR-05 | 16,735 | Flying Dragon | Sun Chu Sha |

# University of Florida Rootstocks (UFR's)

In 2011, we were asked to assess our new rootstock germplasm and release a group of rootstocks that we thought had the best potential against HLB, not waiting for the usual traditional data sets.

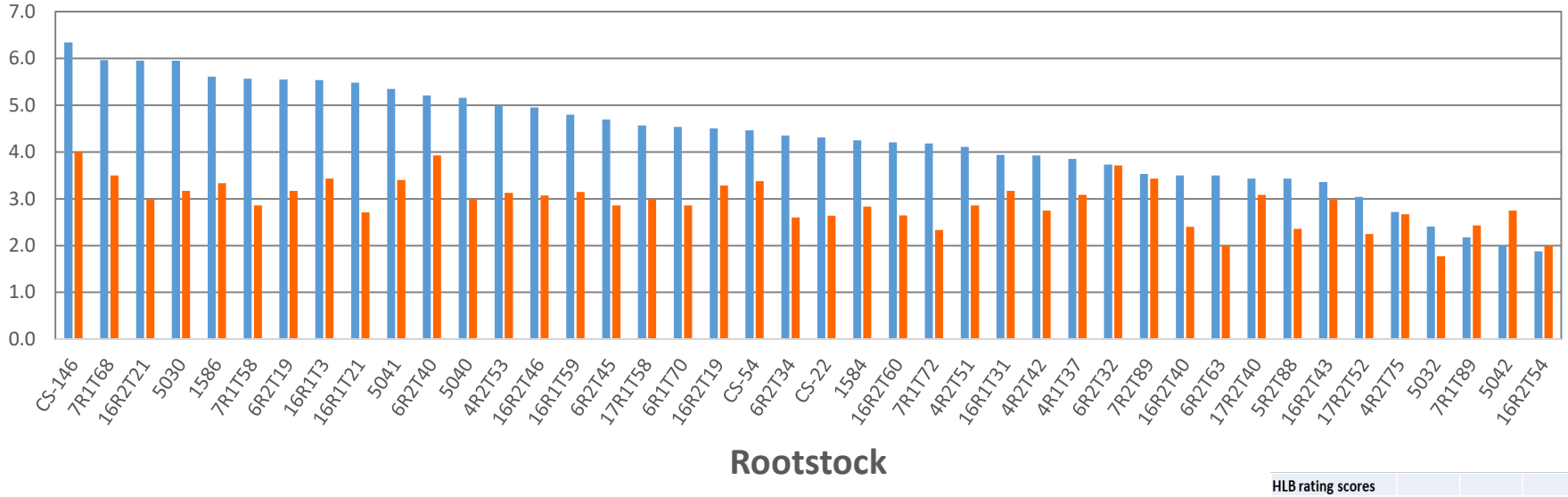
We chose to divide this up into appropriate categories, and we released the following 17 following UFR rootstocks, based on limited but positive data:

Tetraploid Rootstocks: UFR 1-6; 17 (sour orange hybrid)
Citranges: UFR 7-12
Ichangensis hybrid: UFR 13
Sour orange types: UFR 14-16

## Premier Grapefruit Rootstock Trial – Fort Pierce
## Several new citranges performing well!

# Premier Citrus Trial

**Premier Marsh Rootstock Trial - Cum 3-year yield 2010-11, 2011-12, 2015-16 [box/tree] and HLB rating 2017**




HLB ratings

cum 3-year yield  HLB Rating [2017]

| HLB rating scores |
|---|
| 0-0.5 = no HLB symptom or few leave symptoms |
| 1-1.5= 10%-20% HLB symptomatic canopy |
| 2-2.5= 25%-50% HLB symptomatic canopy |
| 3-3.5= more than 50% HLB symptomatic canopy |
| 4= decline to death |

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# NEW STRATEGY: BREEDING SOMATIC HYBRID ROOTSTOCKS AT THE TETRAPLOID LEVEL – CREATION OF **'TETRAZYGS'**

-Use of allotetraploid somatic hybrid breeding parents allows the mixing of genes from 3-4 diploid rootstocks at once.

- Progeny can be screened at the seed/seedling level for wide soil adaptability and Phytophthora resistance.

- Products can have direct rootstock potential including adequate polylembryony, ability to control tree size due to polyploidy, and improved disease resistance.

Candidate for ACPS

Valquarius on Orange #15 tetrazyg rootstock – just < 5 years at St. Helena, Dundee FL – released as UFR-3

# St. Helena Project 2019 Top 30 Data – Rootstock Recovery Contest under Improved Nutrition

| Scion/Rootstock Combination 10-year old trees | PS/Box [2019] | Boxes/Tree [2019] | PS/tree [2019] | Optimum Trees/Acre | Optimum Sq ft/tree [2019] | PS/Acre Projected [2019] (% increase 2019/2018) | Boxes/Acre Projected [2019] (% increase 2019/2018) | cum PS/acre [projected] 2011-19 (9 years of data) |
|---|---|---|---|---|---|---|---|---|
| Vernia:Orange1804 | 6.5 | 3.0 | 19.1 | 207 | 210 | 3951 (150) | 611 (114) | 16509 (9) |
| Vernia:KCZ | 6.9 | 2.6 | 17.7 | 212 | 205 | 3756 (119) | 543 (87) | 13466 (9) |
| Valquarius:Orange1804 | 5.9 | 3.3 | 19.6 | 189 | 230 | 3713 (121) | 629 (95) | 13479 (8) |
| Vernia:Yel1800 | 6.5 | 2.4 | 15.4 | 235 | 185 | 3619 (136) | 559 (122) | 13516 (9) |
| Vernia:Blue1 | 6.5 | 2.5 | 16.0 | 223 | 195 | 3573 (NA) | 546 (173) | 18278 (9) |
| Vernia:MG-11 | 6.8 | 2.3 | 15.6 | 229 | 190 | 3571 (113) | 527 (72) | 16081 (9) |
| Vernia:Orange21 | 6.6 | 1.9 | 12.5 | 281 | 155 | 3518 (129) | 534 (83) | 14550 (9) |
| Vernia:Purple2 | 6.1 | 2.0 | 12.1 | 281 | 155 | 3411 (46) | 556 (21) | 17951 (8) |
| Vernia:Volk | 5.6 | 3.5 | 19.7 | 171 | 255 | 3362 (104) | 604 (84) | 14339 (9) |
| Valquarius:FG1793 | 6.1 | 3.0 | 18.1 | 185 | 235 | 3341 (150) | 551 (139) | 13651 (8) |
| Valquarius:Orange13 | 6.6 | 2.0 | 12.9 | 256 | 170 | 3312 (127) | 502 (93) | 16746 (9) |
| Vernia:Aqua1803 | 6.6 | 2.3 | 15.4 | 203 | 215 | 3131 (114) | 473 (73) | 16612 (9) |
| Vernia:Cleo+CZO | 6.9 | 1.8 | 12.4 | 249 | 175 | 3097 (NA) | 448 (39) | 18089 (9) |
| Vernia:Chang+50-7 [UFR 6] | 7.3 | 1.4 | 10.3 | 300 | 145 | 3079 (249) | 420 (156) | 13902 (9) |
| Valquarius:Amb+HBJL-2B | 6.4 | 2.3 | 14.8 | 207 | 210 | 3067 (223) | 482 (177) | 15128 (8) |
| Valquarius:681G26F4P6 | 6.2 | 2.5 | 15.1 | 198 | 220 | 2993 (70) | 485 (53) | 15716 (8) |
| Valquarius:Aqua1803 | 6.2 | 2.3 | 14.4 | 207 | 210 | 2971 (145) | 482 (112) | 14538 (8) |
| Valquarius:White1805 | 6.1 | 2.8 | 17.2 | 171 | 255 | 2942 (138) | 484 (112) | 15380 (8) |
| Vernia:Wgft+50-7 | 6.7 | 1.9 | 12.3 | 235 | 185 | 2891 (NA) | 435 (104) | 16168 (9) |
| Valquarius:Pink1802 | 6.4 | 1.7 | 10.5 | 272 | 160 | 2868 (73) | 449 (53) | 12977 (9) |
| Vernia:White1805 | 6.9 | 1.4 | 9.9 | 290 | 150 | 2866 (101) | 415 (69) | 13868 (9) |
| Valquarius:MG-11 | 6.0 | 2.1 | 12.4 | 229 | 190 | 2834 (109) | 476 (69) | 13885 (8) |
| Valquarius:FG1707 | 6.8 | 1.9 | 13.2 | 212 | 205 | 2790 (72) | 409 (45) | 14208 (8) |
| Vernia:Orange19 [UFR 4] | 6.4 | 1.9 | 12.2 | 223 | 195 | 2730 (147) | 426 (102) | 14720 (9) |
| Valquarius:FG1733 | 6.3 | 1.8 | 11.4 | 229 | 190 | 2609 (172) | 412 (110) | 15233 (8) |
| Vernia:Orange18 | 6.7 | 1.5 | 10.1 | 256 | 170 | 2573 (NA) | 384 (49) | 13824 (9) |
| Vernia:Orange3 [UFR 1] | 6.8 | 1.6 | 10.8 | 235 | 185 | 2542 (127) | 376 (86) | 12726 (9) |
| Vernia:SWC | 6.7 | 1.8 | 12.1 | 207 | 210 | 2513 (114) | 377 (88) | 12500 (9) |
| Vernia:Purple4 | 7.5 | 1.1 | 7.9 | 311 | 140 | 2466 (NA) | 330 (42) | 15659 (9) |
| Valquarius:Orange3 [UFR 1] | 6.5 | 1.8 | 11.5 | 212 | 205 | 2445 (93) | 377 (82) | 16295 (8) |

# St. Helena Project -Top 15 Among 8-year old trees – 2019 Data
# Rootstock Recovery Contest under Improved CRF Nutrition

| Scion/Rootstock Combination 8-year old trees | PS/Box [2019] | Boxes/Tree [2019] | Optimum Trees/Acre | Optimum Sq ft/tree [2019] | PS/Acre Projected [2019] (% increase 2019/2018) | Boxes/Acre Projected [2019] (% increase 2019/2018) | cum PS/acre [projected] 2011-19 (Years of data) |
|---|---|---|---|---|---|---|---|
| Vernia:46x31-02-13 (UFR-16) | 6.4 | 2.1 | 280 | 155 | 3751 (109) | 582 (89) | 9823 (5) |
| Valquarius:White1 | 6.2 | 3.1 | 189 | 230 | 3615 (238) | 586 (212) | 9682 (6) |
| Valquarius:6058-2071-01-02 | 5.9 | 1.7 | 311 | 140 | 3048 (41) | 513 (32) | 7467 (5) |
| Vernia:46x31-02-S3 | 6.3 | 1.8 | 264 | 165 | 3046 (129 | 486 (104) | 9613 (6) |
| Vernia:Amb+Volk | 6.5 | 1.4 | 293 | 180 | 2666 (136) | 410 (75) | 9909 (6) |
| Vernia:Nova+7-2-99-2 | 6.6 | 1.4 | 272 | 160 | 2548 (139) | 389 (108) | 8203 (6) |
| Valquarius:SO+RPxSH99-5 | 6.9 | 1.1 | 323 | 135 | 2414 (70) | 349 (50) | 10139 (6) |
| Vernia:46x31-02-S9 | 6.9 | 1.1 | 317 | 137 | 2366 (13) | 342 (-2) | 8783 (6) |
| Vernia:Green2 (UFR-17) | 6.3 | 1.8 | 203 | 215 | 2314 (173) | 367 (125) | 8341 (5) |
| Vernia:6058x6056-002 | 5.9 | 1.7 | 218 | 200 | 2104 (92) | 360 (67) | 6070 (5) |
| Vernia:Amb51992 | 6.5 | 1.0 | 300 | 145 | 1855 (69) | 285 (48) | 8372 (6) |
| Vernia:6058-2071-01-02 | 6.4 | 1.1 | 264 | 165 | 1771 (99) | 277 (86) | 7271 (6) |
| Vernia:A-Mac | 6.2 | 1.1 | 242 | 180 | 1674 (-10) | 269 (-23) | 7135 (6) |
| Vernia:SO+RPxSH99-4 | 6.1 | 1.0 | 281 | 155 | 1665 (88) | 273 (91) | 3989 (5) |
| Vernia:Wmur+HBJL-7 | 6.7 | 1.0 | 235 | 185 | 1500 (13) | 223 (10) | 6837 (6) |

**UFR-17 Emerging as good HLB-tolerant rootstock for higher-density plantings.**

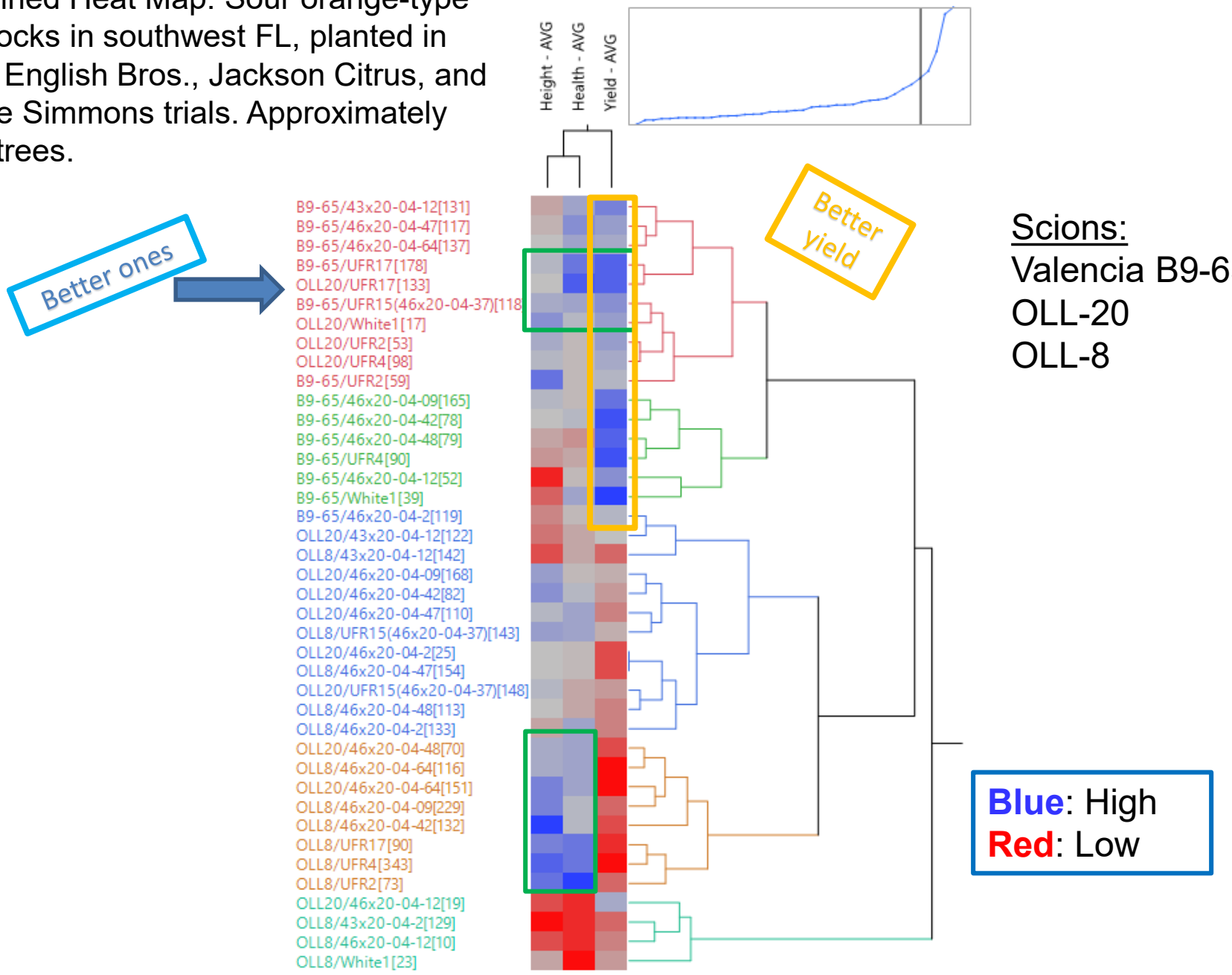
OLL-8 on UFR-17, February 2018

July 2018

February 8, 2019

6-year old Valencia/UFR-17 resets at Orie Lee Alligator Grove; HLB+ over 4 years, grownwith no psyllid control; picked 2.13 boxes/tree in 2018 season; 2.5 in 2019. UFR-17 is [Nova+HBPummelo x sour orange+Carrizo].

Combined Heat Map: Sour orange-type rootstocks in southwest FL, planted in 2014, English Bros., Jackson Citrus, and Wayne Simmons trials. Approximately 5000 trees.




Scions:
Valencia B9-65
OLL-20
OLL-8

**Blue**: High
**Red**: Low


9-year old Valencia on 46x20-04-6 (HB Pummelo x Cleo) grown at Lee Alligator Grove (St. Cloud) with only 2 psyllid sprays per year and no special nutrition.

# Time is the Enemy

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Plant species have thrived for thousands of years in the presence of evolving, hostile pathogens – HOW? They have created their own genetic diversity, and through the process of natural selection, tolerant or resistant genotypes overcome the threat and allow the species to evolve.

In Citrus, this process has been largely interrupted by man, with Citriculture now approaching monoculture – leading to the problem that has brought us all together.

Facilitated by biotechnology, citrus breeders have the opportunity to artificially reinstate this process by creating broad and unique genetic diversity from elite parents, followed by robust screening. Maybe this is the answer for solving the HLB and other disease problems!

# The New Gauntlet in the HLB world
# High Throughput Screening Method
# >12,000 hybrids screened to date

1. Crosses of superior parents made at diploid and tetraploid levels
2. Seed harvested from crosses planted in bins of calcareous soil (pH=8), inoculated with *P. nicotianae* and *P. palmivora* (JH Graham)
3. Selection of robust seedlings based on growth rate, health and color (most don't make it!)
4. Transfer to 4x4 pots in commercial potting soil
5. Top of new tree goes for seed source tree production; remaining liner to the HLB screen
6. Hybrid liner is grafted with HLB-infected budstick of Valencia sweet orange; remaining rootstock top removed, forced flushing from HLB-infected sweet orange budstick
7. Trees monitored for HLB symptoms – healthy appearing trees entered into 'hot psyllid' house for 4 weeks, followed by field planting at Picos Farm (under DPI permit).

Rootstock cross with good Phytophthora resistance.

Gauntlet trees are produced by 'stick' grafts. HLB-infected Valencia budsticks wrapped in parafilm are grafted into selected rootstock candidates. Rootstock tops are used to produce rooted cuttings for seed trees on their own roots.

Quite often the first flush is symptom free, selection is based on the 2nd flush, which usually shows symptoms.

2016 Field Planting will include trees on left; featuring 3 superior crosses: C2-5-12 pummelo x papeda; A+HBP x White 1 and A+HBP x sour orange+rangpur. Candidates on left already passed through the 'hot psyllid' house.

## Gauntlet Survivor at Picos Farm
## –Valencia on Milam+HBP x Orange #14–09–14

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## Gauntlet Survivor at Picos Farm
## –Valencia on Milam+HBP x Orange #14–09–14

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Two complex ‘tetrazyg’ rootstocks performing well in the ‘gauntlet’ HLB screen are now making polyembryonic seed, allowing for rapid large scale testing – now underway (above: Milam+HBPxOrange 14-09-10 and A+VolkxOrange 19-11-8). Trees on right were budded with our new early Valencia release EV-1. These and other selections have been entered into the DPI Parent Tree Program and are being provided to rootstock tissue culture micropropagation companies.

**1. Genetic Patterns Emerging! Gauntlet trees showing promise – complex tetraploids, combining phloem regeneration capacity from the lemon group with the feeder root preservation trait of Orange 19 (and sibling Orange 14).**

A+Volk x Orange 19-11-23
A+Volk x Orange 19-11-9
A+Volk x Orange 19-11-26
A+Volk x Orange 19-11-8
**A+Volk x Orange 19-11-31**
**A+Volk x Orange 19-11-1**
A+Volk x Orange 19-11-5
A+Volk x Orange 19-11-13
Milam+HBP x Orange 14-09-3
Milam+HBP x Orange 14-09-19
Milam+HBP x Orange 14-09-12
Milam+HBP x Orange 14-09-9
Milam+HBP x Orange 14-09-4
Milam+HBP x Orange 14-09-6
**Milam+HBP x Orange 14-09-14**
**Milam+HBP x Orange 14-09-10**
**Milam+HBP x Orange 14-09-11**

**2. Genetic Patterns Emerging! Gauntlet trees showing promise from rootstock hybrids stacked with abiotic stress tolerance genes (HLB is a stress reactive disease).**

Sour orange types:

S10xS11-11-S20 (salt tolerant Shekwasha/pummelo)
**S10xS15-12-25 (salt tolerant Shekwasha & Cleo/pummelo)**
**S10xS15-12-48 (salt tolerant Shekwasha & Cleo/pummelo)**
S10xS15-12-35 (salt tolerant Shekwasha & Cleo/pummelo)
S10xS15-12-32 (salt tolerant Shekwasha & Cleo/pummelo)
S10 x x639-12-16 (salt tolerant Shekwasha/Cleo/trifoliate orange
S10 x x639-12-31 (salt tolerant Shekwasha/Cleo/trifoliate orange
46x31-00-S10 x US812-11-2 (salt tolerant Shekwasha, Sunki, trifoliate orange)

46x31-02-S10x46x20-04-S15-12-25

46x31-02-S10x46x20-04-S15-12-48

Hybrids selected for abiotic stress tolerance performing exceptionally well in ‘gauntlet’ rootstock screen. Abiotic stress tolerance and HLB- biotic stress tolerance genetics may overlap! Rootstocks of above trees (grown with HLB+ Valencia) are hybrids of parents both previously selected for tolerance to 3500 ppm NaCl; [Hirado buntan pummelo x Shekwasha mandarin] x [Hirado buntan pummelo x Cleopatra mandarin]. Tree on right was HLB+ in 2016, HLB- in 2017!

S10xS15-12-25 (Shekwasha/Cleo/pummelo)

Several hybrids of 8-1-99-2B x C22 (pummelo x citrandarin)

**GAUNTLET rootstock screening (Final stage at USDA-Picos Farm, Fort Pierce, FL); HLB+ Valencia trees grown from the get-go with Clas-infected budsticks; also passed through a hot psyllid house. More than 10,000 hybrids screened to date. Some now in large-scale trials!**

# Is HLB-Resistance in the Scion Possible from a Rootstock?

| CLas Non-Detected | | |
|---|---|---|
| 1. | S10xX639-12-4 | NR |
| 2. | S10xS15-12-25 | 4 |
| 3. | S10xS15-12-33 | 3 |
| 4. | 8-1-99-2BxC-22-12-32 | 4 |
| 5. | A+VolkxOrange19-11-24 | 3 |
| 6. | B11-R5-T25-11-6 | 3 |
| 7. | Milam+HBPxOrange14-09-19 | 4 |
| 8. | B11-R5-T4-11-2 | 4 |
| 9. | S10xS15-12-29 | 4 |
| 10. | A+HBPxCH+50-7-12-57 | 4 |
| 11. | S10xX639-12-7 | 3 |

***Table 3**. Grosser/Gmitter: 2019 qPCR (Cano) older 'gauntlet' trees showing non-active CLas infection – potential resistance being transmitted to the Valencia scion? Trees 4-6 years old at USDA-Picos Farm.*

Sour+Rangpur Seed Tree

HLB+Valencia/ A+HBPxSORP-13-29

Genetic Pattern 3. Gauntlet HLB+ Valencia on a complex rootstock hybrid of Amblycarpa+HBPummelo x Sour orange+Rangpur. The Sour orange+Rangpur parent seed trees are planted at 3 locations, and all are exceptionally tolerant of HLB. However, it does not make a good rootstock itself due to slow growth and excessive zygotic seed production. Hybridizing it with the tolerant A+HBP parent has corrected the vigor problem!

| Top Performing Gauntlet Rootstock Status | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| Rootstock | Seed Tree | Producing Seed | PTP Status | TC | MAC |
| | | | | | |
| A+VolkxOrange19-11-8 | Yes | Yes | Available | Yes | Yes |
| Milam+HBPxOrange14-09-10 | Yes* | Yes* | In process | Yes | Yes |
| A+VolkxOrange19-11-31 | Yes | No | Available | Initiated | No |
| A+HBJL1-OP-09-36 (sour type) | No | No | Soon | No | No |
| Milam+HBPxOrange14-09-9 | No | No | Soon | No | No |
| Milam+HBPxOrange14-09-14 | No | No | Available | Initiated | No |
| A+HBPxOrange19-08-2 | Yes | Zygotic | Available | Initiated | No |
| | | | | | |
| Flying Dragon Hybrids (for ACPS) | | | | | |
| B21-R1-T2-11-2 | No | No | Available | No | No |
| B21-R1-T25-11-10 | No | No | Available | No | No |
| B21-R1-T25-11-6 | No | No | Available | No | No |
| A+FDxOrange19-11-10 | Yes | Yes | Soon | No | No |
| | | | | | |
| R&D Tissue Culture Collaborators: Phillip Rucks Nursery TC Lab and Agromillora FL | | | | | |

# Sugar Belle (LB8-9) Rootstock Hybrid Cuttings Inventory

| Hybrid* | Number | | Hybrid* | Number | | Hybrid* | Number |
|---|---|---|---|---|---|---|---|
| LB8-9 X S10-15-5 | 5 | | LB8-9 X S13-15-1 | 8 | | Sugar Belle LB-Zyg x 50-7-16-25 | 11 |
| LB8-9 X S10-15-7 | 10 | | LB8-9 X S13-15-2 | 5 | | Sugar Belle LB-Zyg x 50-7-16-26 | 12 |
| LB8-9 X S10-15-9 | 6 | | LB8-9 X S13-15-4 | 6 | | Sugar Belle LB-Zyg x 50-7-16-23 | 13 |
| LB8-9 X S10-15-10 | 6 | | LB8-9 X S13-15-6 | 12 | | Sugar Belle LB-Zyg x 50-7-16-6 | 22 |
| LB8-9 X S10-15-11 | 8 | | LB8-9 X S13-15-8 | 9 | | Sugar Belle LB-Zyg x 50-7-16-12 | 15 |
| LB8-9 X S10-15-12 | 7 | | LB8-9 X S13-15-9 | 5 | | Sugar Belle LB-Zyg x 50-7-16-7 | 21 |
| LB8-9 X S10-15-14 | 5 | | LB8-9 X S13-15-10 | 4 | | Sugar Belle LB-Zyg x 50-7-16-5 | 8 |
| LB8-9 X S10-15-17 | 5 | | LB8-9 X S13-15-11 | 8 | | Sugar Belle LB-Zyg x 50-7-16-4 | 33 |
| LB8-9 X S10-15-18 | 13 | | LB8-9 X S13-15-12 | 5 | | LB8-9 x 50-7-16-4 | 4 |
| LB8-9 X S10-15-19 | 10 | | LB8-9 X S13-15-13 | 8 | | LB8-9 x 50-7-16-2 | 8 |
| LB8-9 X S10-15-20 | 9 | | LB8-9 X S13-15-14 | 6 | | | |
| LB8-9 X S10-15-21 | 4 | | LB8-9 X S13-15-15 | 8 | | | |
| LB8-9 X S10-15-25 | 11 | | LB8-9 X S13-15-16 | 6 | | | |
| LB8-9 X S10-15-28 | 5 | | LB8-9 X S13-15-18 | 4 | | | |
| LB8-9 X S10-15-29 | 7 | | LB8-9 X S13-15-22 | 6 | | | |
| LB8-9 X S10-15-30 | 11 | | LB8-9 X S13-15-23 | 4 | | | |
| LB8-9 X S10-15-41 | 11 | | LB8-9 X S13-15-24 | 7 | | | |
| LB8-9 X S10-15-47 | 4 | | | | | | |
| LB8-9 X S10-15-15 | 5 | | | | | | |
| LB8-9 X S10-15-16 | 2 | | | | | | |
| | **144** | | | **111** | | | **147** |

*Name: Sugar Belle X OP Pummelo + Trifoliate 50-7-XX-X (The Last Number is designates the sibling #. LB-ZYG = Lime Block Zygotic
Or LB8-9 X OP Pumelo + Trifoliate 50-7-XX-X

# SugarBelle Rootstock Hybrids – Moving Through the ‘Gauntlet’

No stone unturned! Left: HLB+Valencia on SugarBelle x 46x20-04-S15 (15-16), under heavy psyllid pressure; Right: HLB+Valencia on various SugarBelle rootstock hybrids prepared for ‘Gauntlet’ field screen at USDA-Picos Farm in Fort Pierce.

# UF/CREC-Germplasm into MAC Trials

**1. Rogers MAC Project – CREC Lake Alfred (planted)**

- 70 sweet orange/rootstock combinations (19 early orange; 51 late orange); SugarBelle on 4 rootstocks; all new rootstock candidates from the UF/CREC citrus improvement program.
- Plot size: 50 trees/plot; >12,000 trees, four plots for most combinations; 70+ acres

**2. Grosser/Gmitter/Bowman MAC Rootstock Project (planted)**

- Vernia/Valencia B9-65 and OLL-8 on 48 rootstocks (24 from UF)
- 12 trials, 12 4-tree replications, nearly 16,000 trees all planted

**3. Vidalakis/McCollum MAC Project – CA/FL- Experiment 1 – HLB Tolerant Rootstock Effects on Fruit Quality (first planting underway)**

- 5 standard scions on 12 improved rootstocks (6 from UF);3 Sites in Florida, 7 replications per site, 3780 trees

**4. Vidalakis/McCollum MAC Project – CA/FL - Experiment 2 – Evaluation of <u>Putatively HLB Tolerant</u> Scions**

- Four Control Scions: Valencia, Hamlin, Tango & SugarBelle; 6 UF and 7 USDA mandarins (13 total selections);7 UF and 5 USDA sweet orange/sweet orange-like (12 total selections); includes several true sweet oranges, 3 sites, 18,900 trees on US-942

# New Lykes Trials: Camp Mack and Basinger

Working with John Gose and the Lykes Nursery, two major sister 40-acre rootstock trials replicated at two sites: Camp Mack and Basinger.  11/12 replications per rootstock.

Hamlin on 57 rootstocks
Valencia on 52 rootstocks

Rootstocks included from UF, USDA, CA and Spain

We have collected 2 years of young tree data, and will work with colleague Dr. Ute Albrecht (PI on the Trial Evaluation Project) to continue robust data collection and analysis.

# Improving delivery of trial information to growers

- Citrus Improvement Team Website Now Online – one stop shopping for growers/processors, packers. Data from 10 trials at present
- Website will eventually have tabs to General Information, CRDF supported trials, MAC trials, and NIFA grant progress.
- Our team hired Dr. Filomena Valim to facilitate trial data statistical analyses and easily understood presentations.
- Website will also provide links to FFSP, NVDMC, etc. for information on scion and rootstock access/licensing, etc.

**Rootstock improvements regarding HLB are like likely to come in stages:**

First stage: Rootstocks that reduce the frequency of HLB infection, and reduce the severity of the disease once infected – already proven to work with mid- and late-season oranges when grown with optimized nutrition programs focusing on root health.

Second stage: Potential rootstock mitigation of the disease – research is underway to possibly identify rootstocks that can protect the entire tree – regardless of the scion. Psyllid control may not be necessary. No horticultural performance data would be available on such selections initially, but the hybrids would have good rootstock pedigree, and can be mass-propagated by tissue culture (Ruck's Nursery, Agristarts, Agromillora, Citrific, etc.).

Many of the most promising hybrids have been entered into expanded field trials via MAC grants. The first MAC grant (w/ Kim Bowman @ USDA) is testing 48 new rootstocks (24 from UF and 24 from USDA) with industry cooperators at 9 locations. The 2nd 'Rogers' MAC grant is testing 79 scion/rootstock combinations in LA. A third MAC grant will test putatively tolerant scions and rootstocks in Florida and California (w/ Vidalakis and McCollum, USDA). Numerous other trials are also planned and underway.

- Renewed field team personnel
- More grove visits in the last 2 years than ever before
- More data collected in the past year than ever before
- New focus on summary reports from field trials
- New web presence now online and being expanded

# A few more things…

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# CONCLUSIONS

- Enhanced ground nutrition featuring ‘hybrid’ programs that include CRF and/or liquid applications can help restore and sustain production from HLB-infected trees – but it takes time!

# The Ticket For the Immediate Future

Improved Scion Genetics for HLB Tolerance

Plus

Improved Rootstock Genetics for HLB Tolerance

Plus

Improved Affordable Production Systems w/ Enhanced Root Nutrition

# $$ Success $$

# THANK YOU CRDF!

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