UF-Plant Science Research and Education Unit [PSREU] Scion-Rootstock Trial

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CREC Citrus Plant Improvement

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UF-PSREU Scion/Rootstock Trial- Description

The UF site of about 3 acres was intended to primarily be a place for the testing of over-the-row harvesting equipment being developed by Dr. Tom Burks. To that end, a three-layer windbreak composed of slash pine, Eucalyptus and red cedar was planted in February 2007 around the entire trial site. Citrus trees were planted in March 2007 in North-South rows all 20 feet apart assigned as follows: 4 rows of Sunburst mandarin at 12 x 20 feet, 3 rows of Ray Ruby including a few Flame grapefruit on Flying Dragon trifoliate orange at 8 x 20; also, 3 rows of Valencia/Swingle citrumelo @ 10 x 20, 4 rows of Hamlin/Cleopatra mandarin @ 12 x 20 and 2 rows of navel orange/Swingle @ 12 x 20 ft.

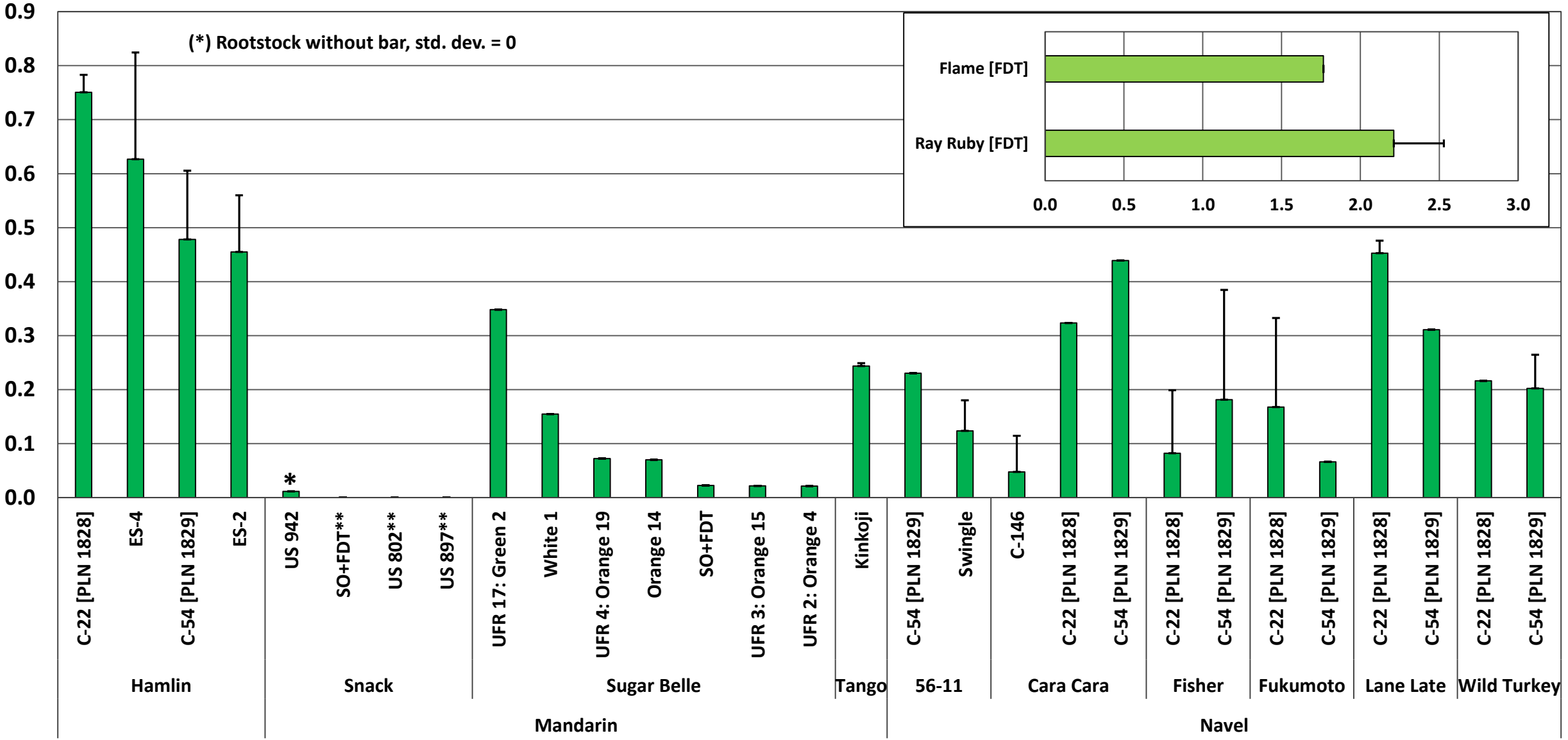
All but the grapefruit and navel orange trees were removed in 2014 because of large tree size and Huanglongbing. Replacement trees consisting of 5 navel orange selections, Hamlin and two new mandarin types on various size-controlling rootstocks were planted in May 2014 [see next section for details].

UF-PSREU Scion/Rootstock Trial - Summary

- Location: Citra, Marion County.
- Scions: Navel orange: 56-11, Cara Cara, Fisher, Fukumoto, Lane Late and Wild Turkey; Hamlin, Mandarin: Snack, Sugar Belle, Tango; Grapefruit: Ray Ruby
- Rootstocks: UFRs and Bitters, Furr and C-146; US 802, 897 and 942
- Date planted: Ray Ruby/Flying Dragon [March 2007]; others [May-June 2014]
- Design: Single plots
    - Plot size: 4-60 trees
    - Spacing: 8 x 20 ft. = 272 trees/acre.
    - Microsprinkler irrigation
- Data:
    - 2014-15 & 2015-16: Yield [boxes/tree]
    - 2016-17: Yield [boxes/tree] & [boxes/acre]
    - 2017-18: Yield [boxes/tree]
    - 2018-19: Juice quality
    - 2019-20: Yield [boxes/tree]
    - 2020-21: HLB Ratings
    - Cumulative yield [boxes/tree]: 3-year oranges and mandarins & 2-year grapefruit*

        ** Yields were low in the first bearing years so only the data for seasons 2016-17, 2017-18 & 2019-20 were used to compile cumulative yield for oranges and mandarins and data for seasons 2017-18 & 2019-20 were used for grapefruit.*
- **Trial status: ACTIVE, but modified. Certain trees were removed in 2020.**

Fig. 1. UF-PSREU scion/rootstock trial – Yield: mean + std. dev. [boxes/tree, January 2017].



(**) Yield = 0

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Fig. 2. UF-PSREU scion/rootstock trial – Yield [boxes/tree, March 2018].

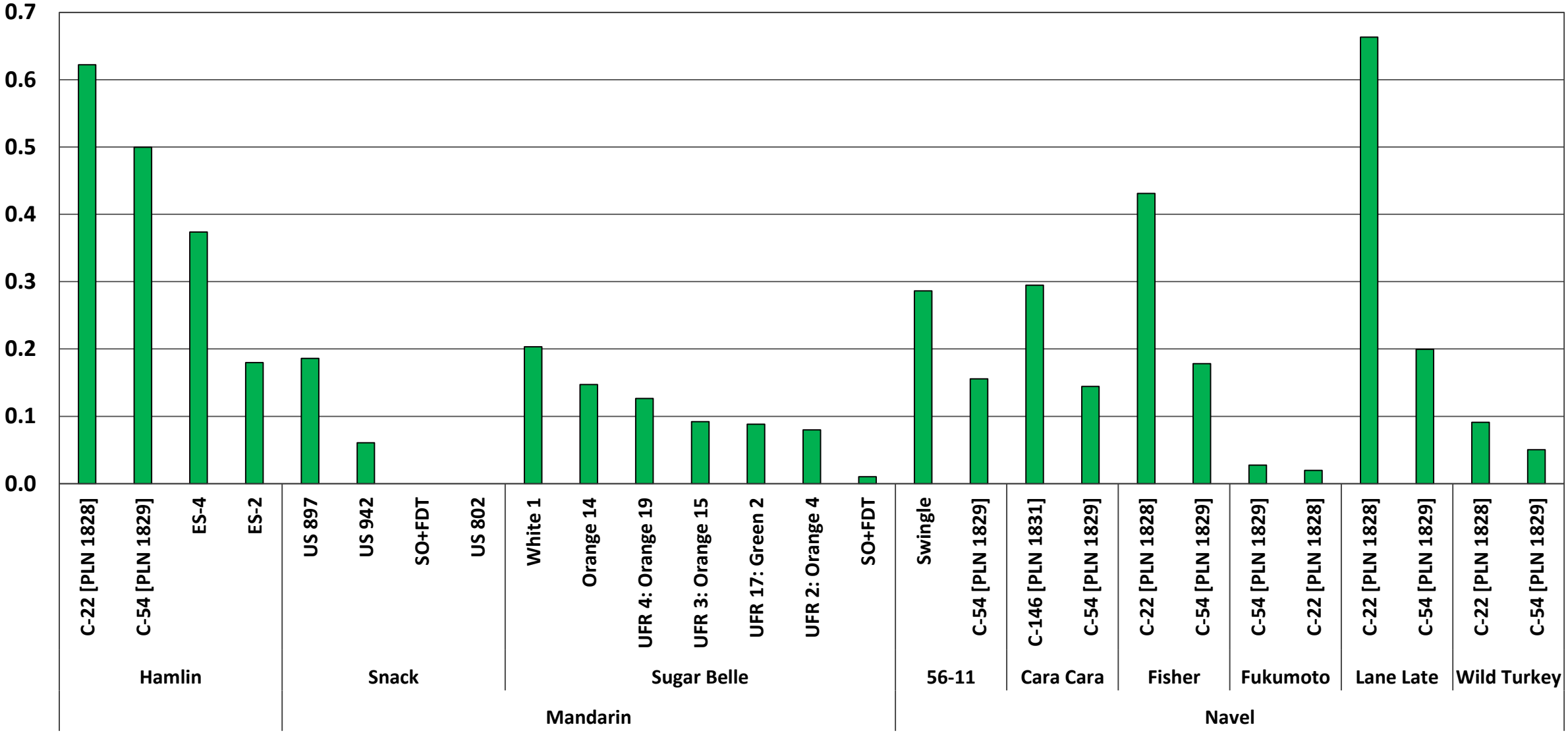

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Fig. 3. UF-PSREU scion/rootstock trial – juice Acid: mean + std. dev. [December 2018].

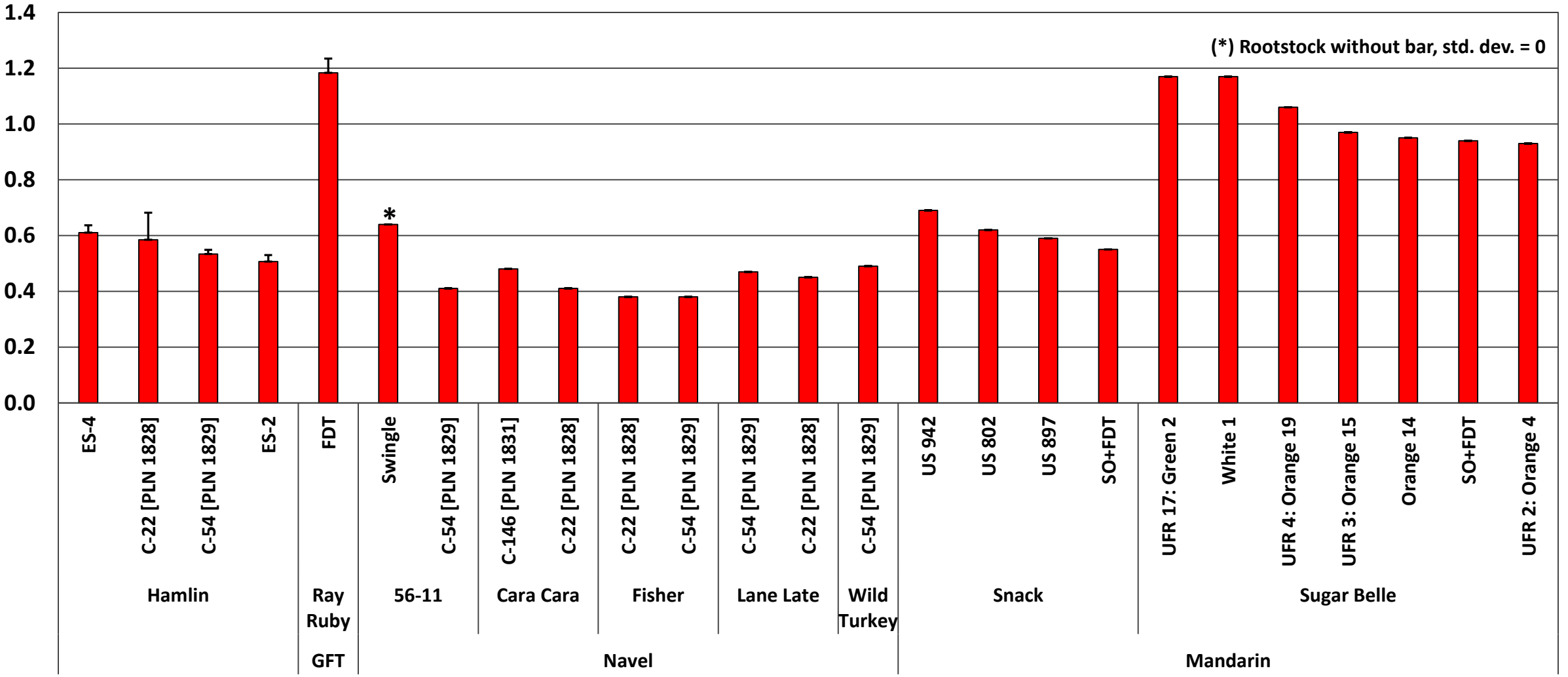

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Fig. 4. UF-PSREU scion/rootstock trial – juice Brix: mean + std. dev. [December 2018].

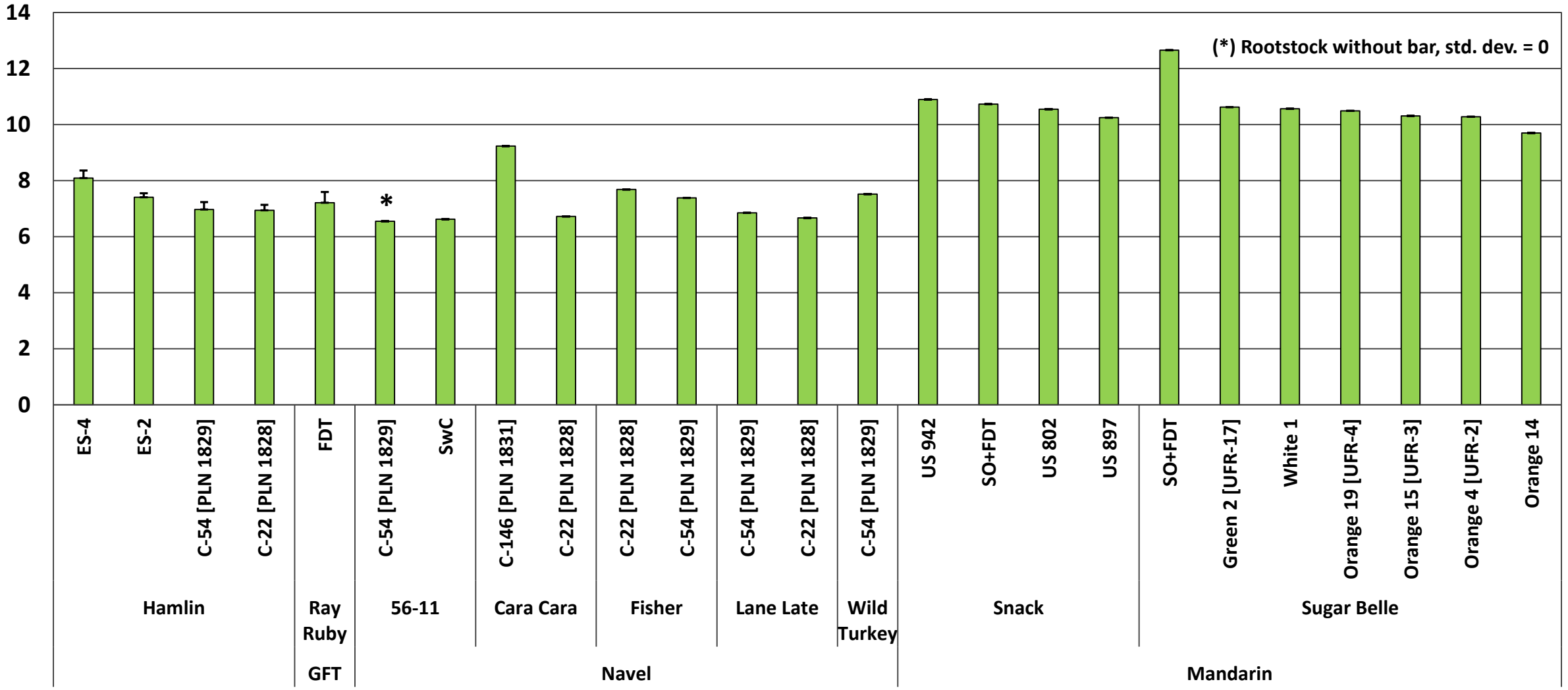

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Fig. 5. UF-PSREU scion/rootstock trial – juice Ratio: mean + std. dev. [December 2018].

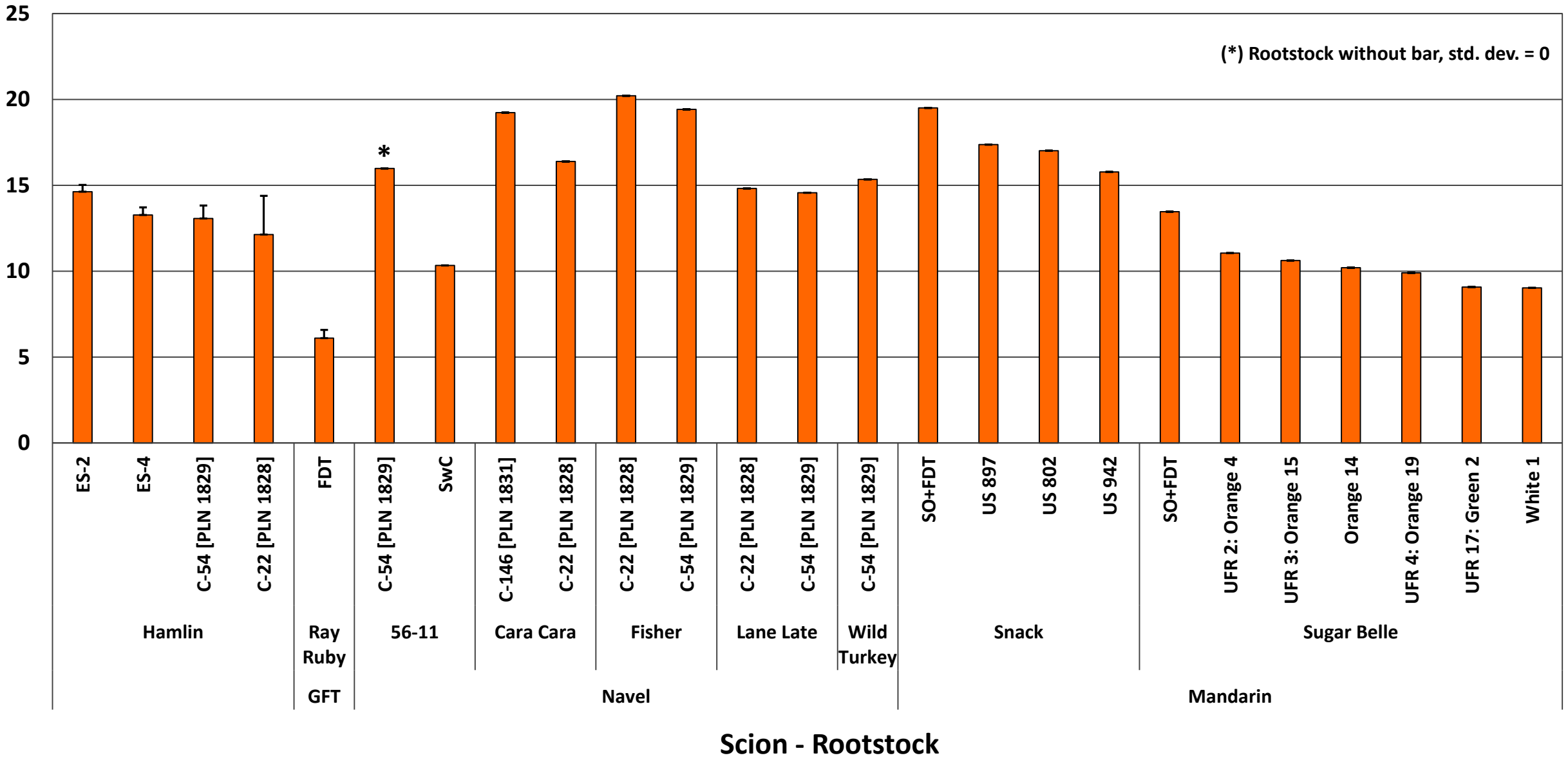

Fig. 6. UF-PSREU scion/rootstock trial – PS/box: mean + std. dev. [December 2018].

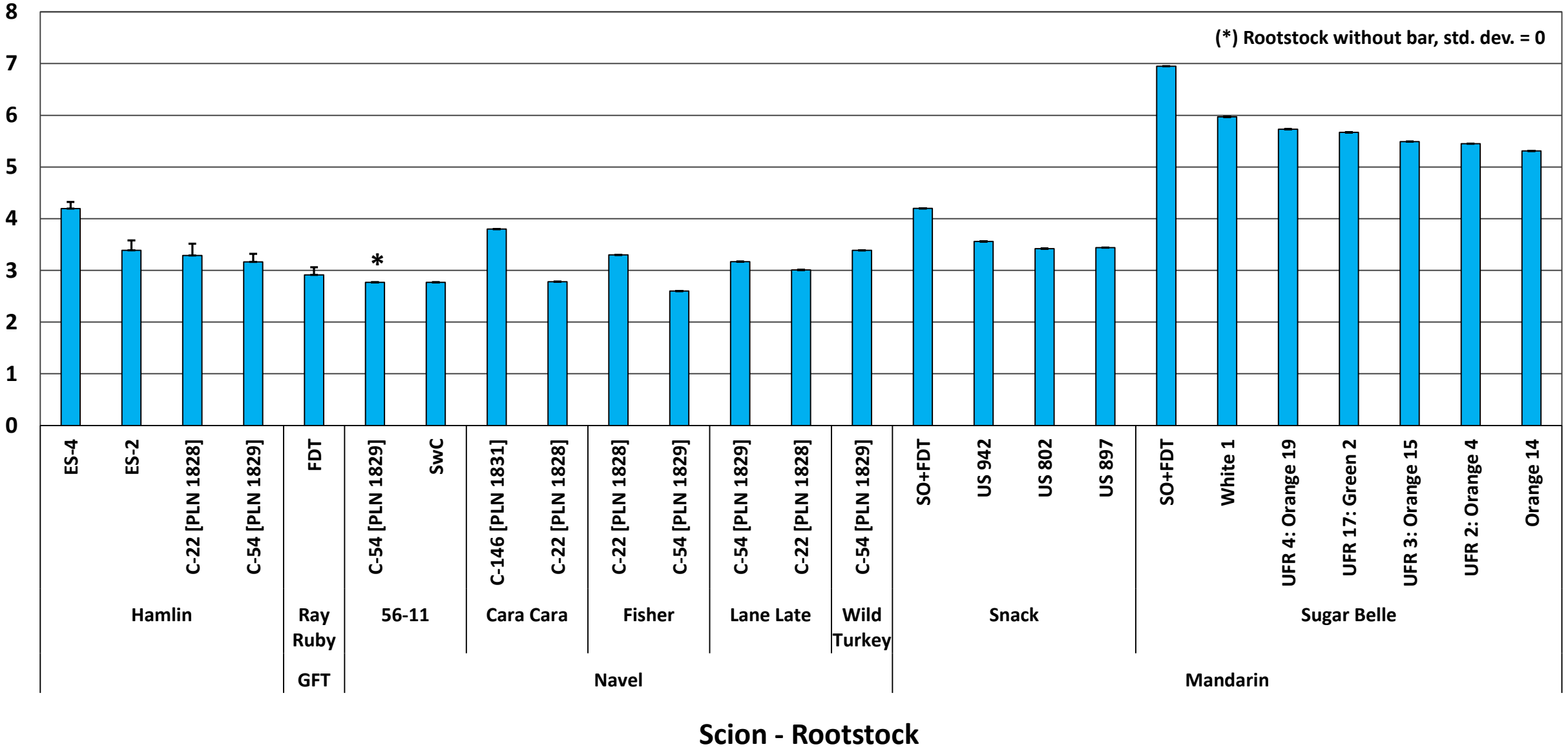

Fig. 7. UF-PSREU scion/rootstock trial – juice Color: mean + std. dev. [December 2018].

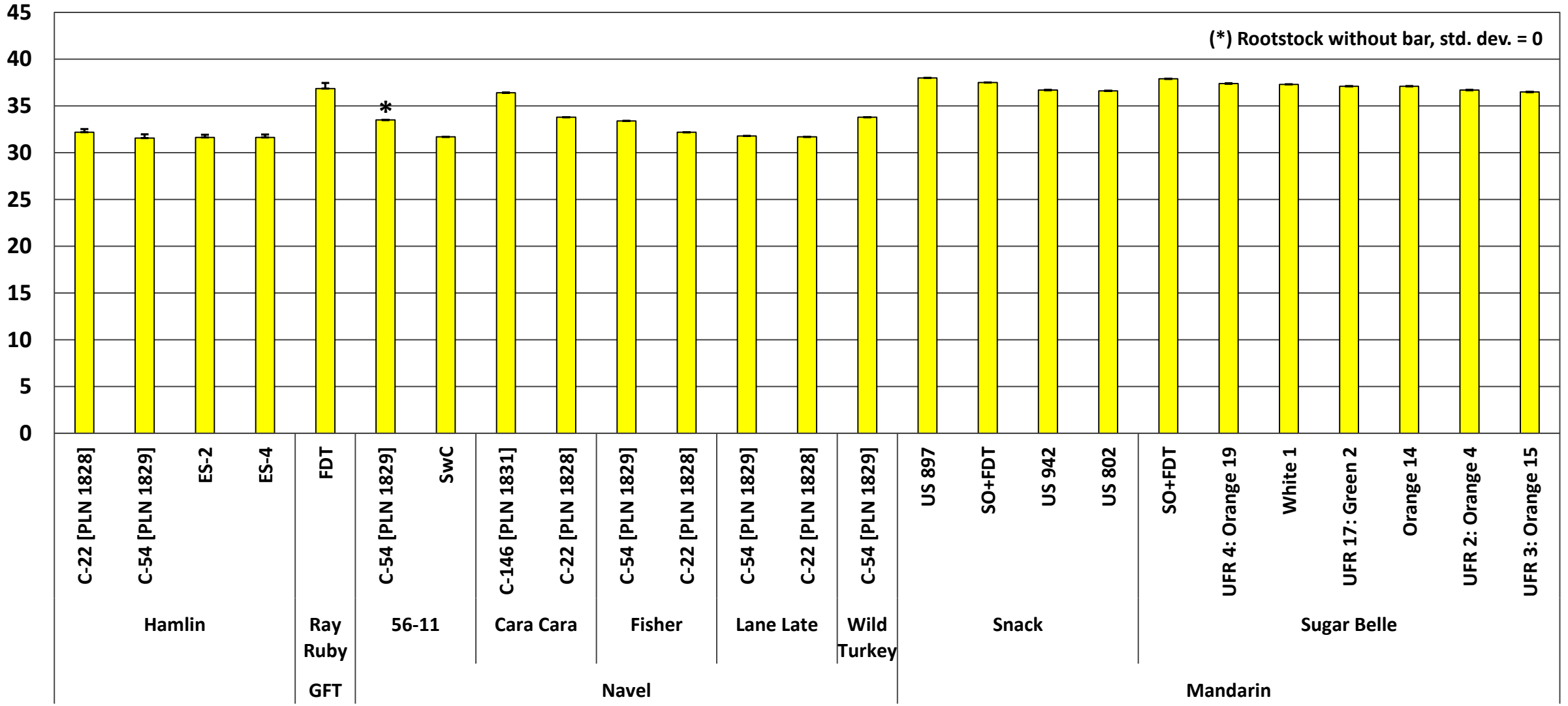

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Fig. 8. UF-PSREU scion/rootstock trial – Yield: mean + std. dev. [boxes/tree, January, 2020].

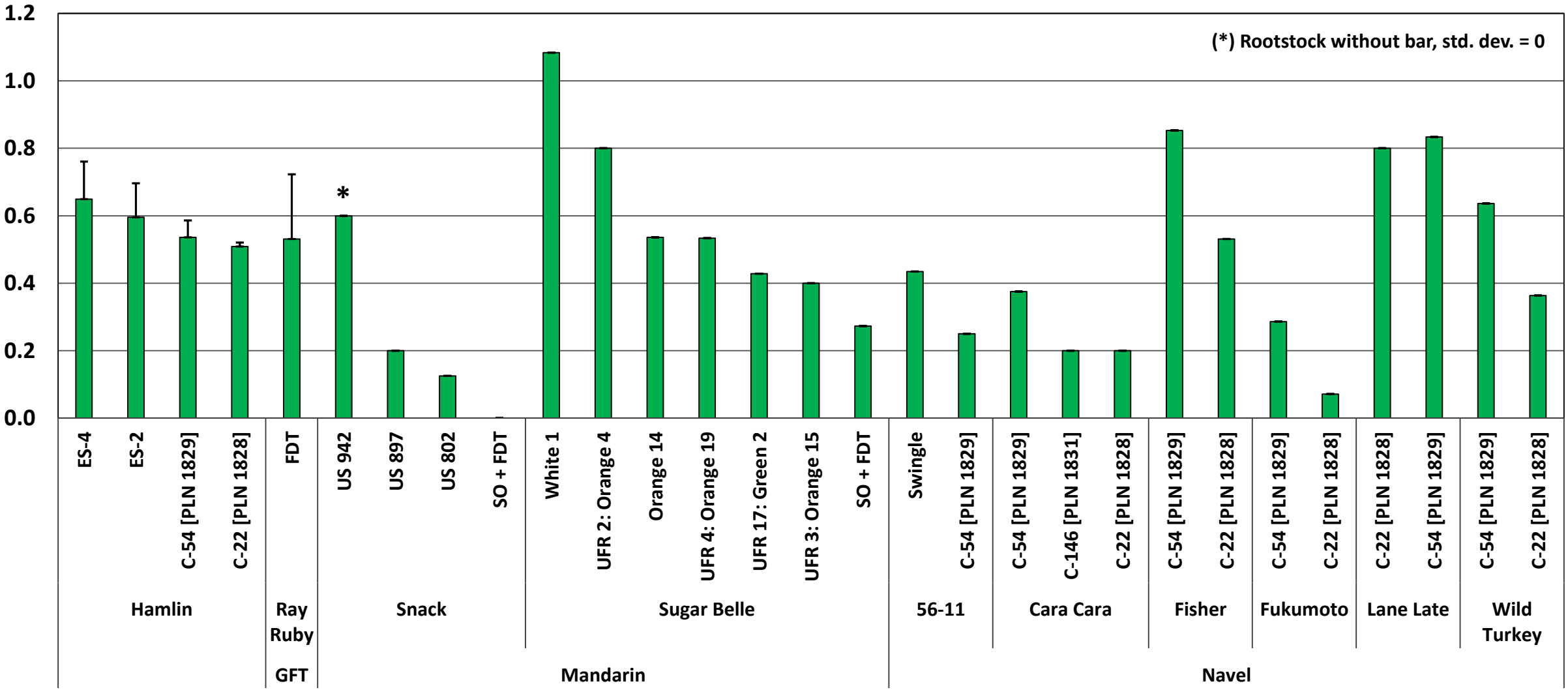

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Fig. 9. 2019-20 UF-PSREU scion/rootstock trial – juice Acid: mean + std. dev. [January, 2020].

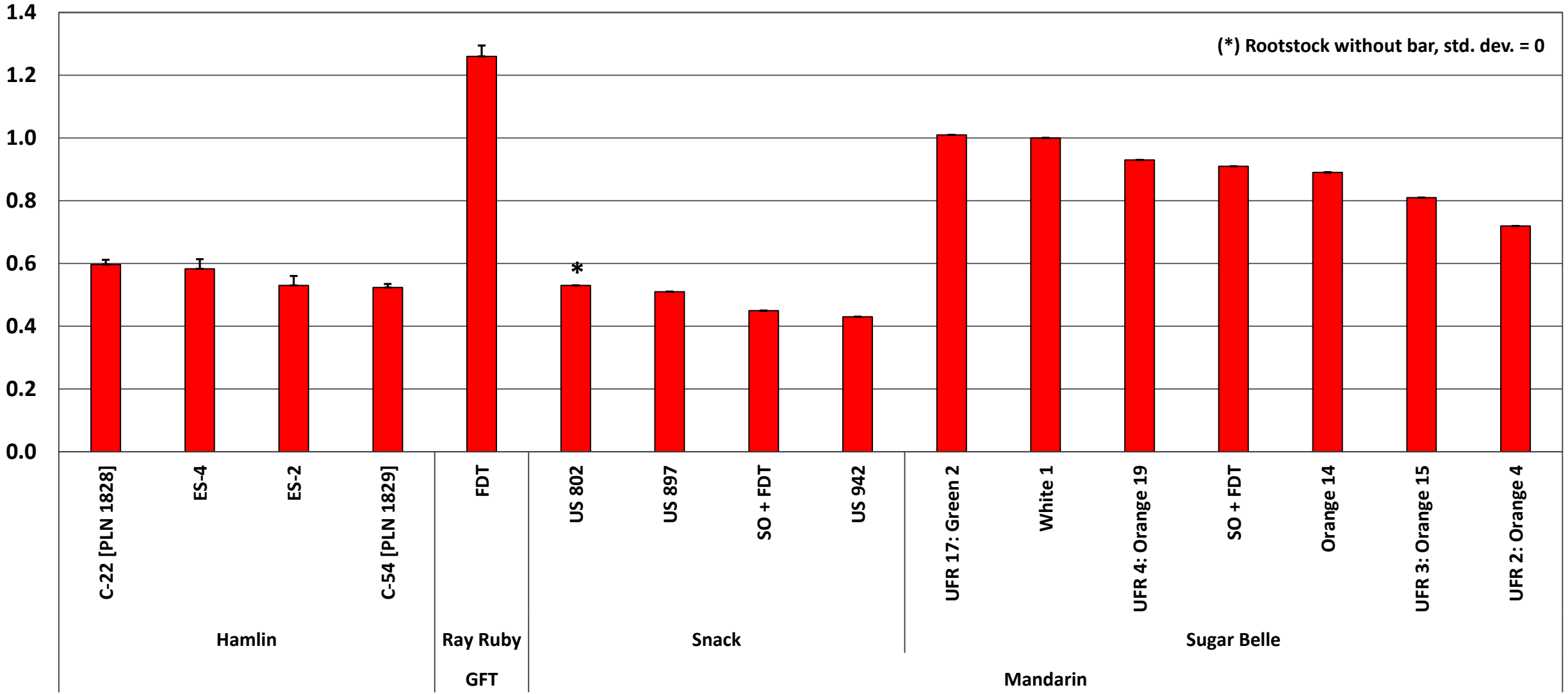

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Fig. 10. UF-PSREU scion/rootstock trial – Brix: mean + std. dev. [January, 2020].

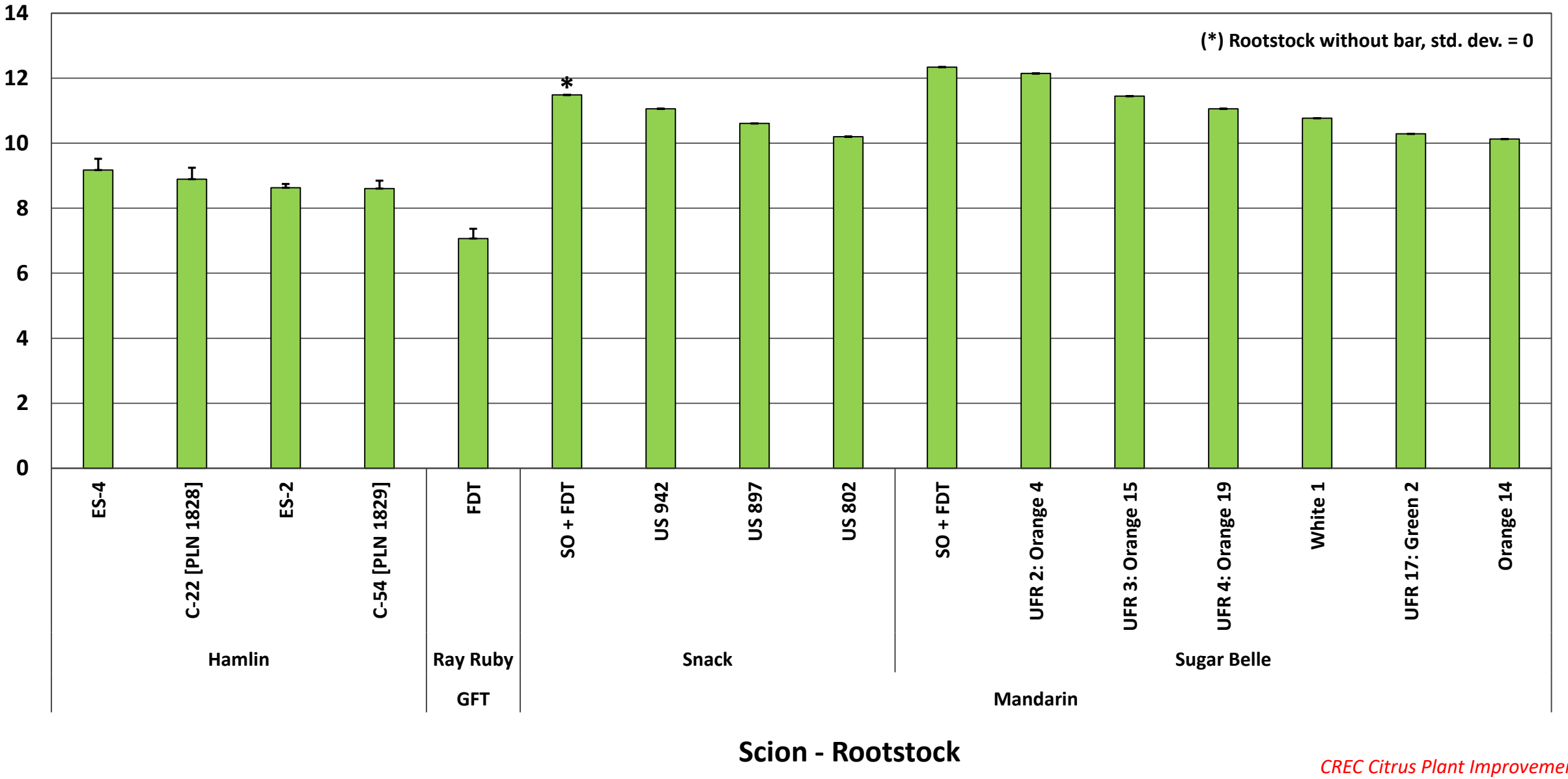

Fig. 11. UF-PSREU scion/rootstock trial – juice Ratio: mean + std. dev. [January, 2020].

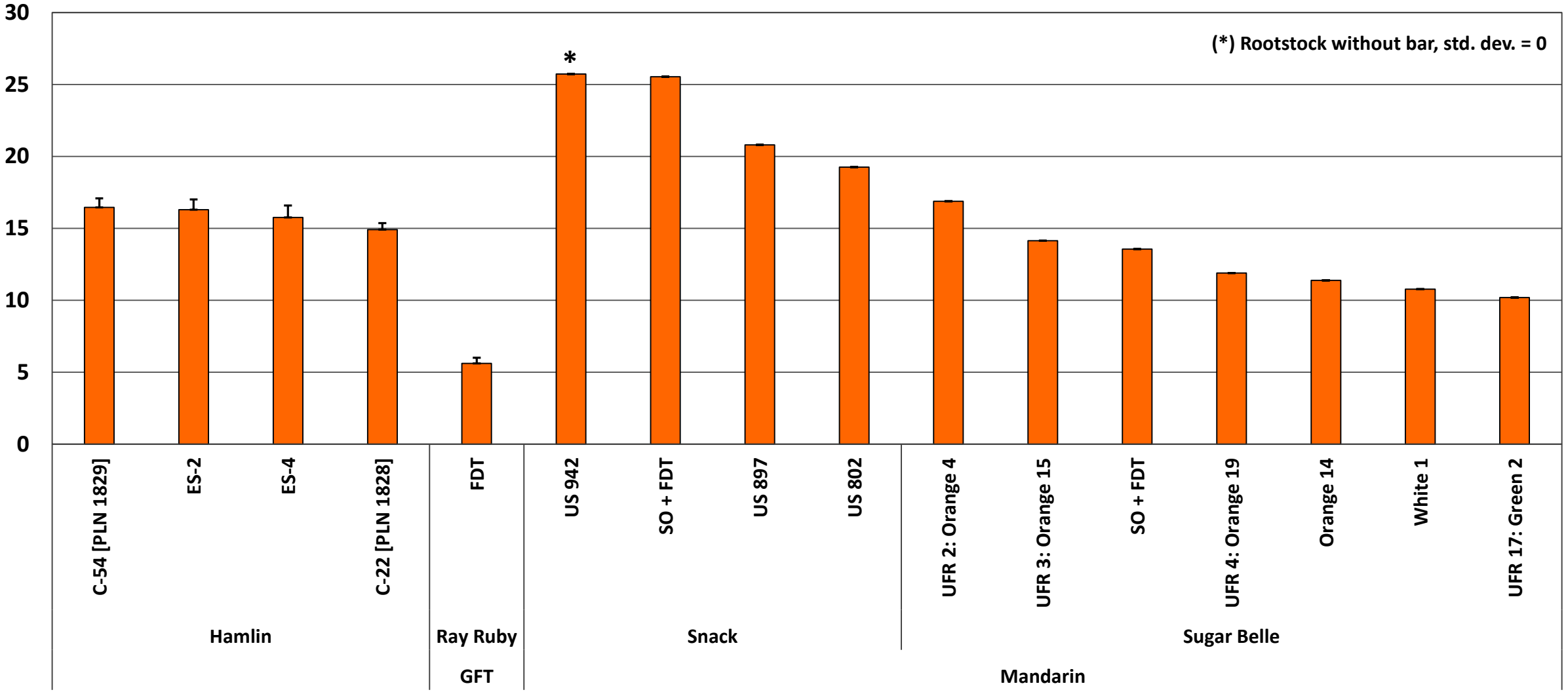

Fig. 12. UF-PSREU scion/rootstock trial – PS/box: mean + std. dev. [January, 2020].

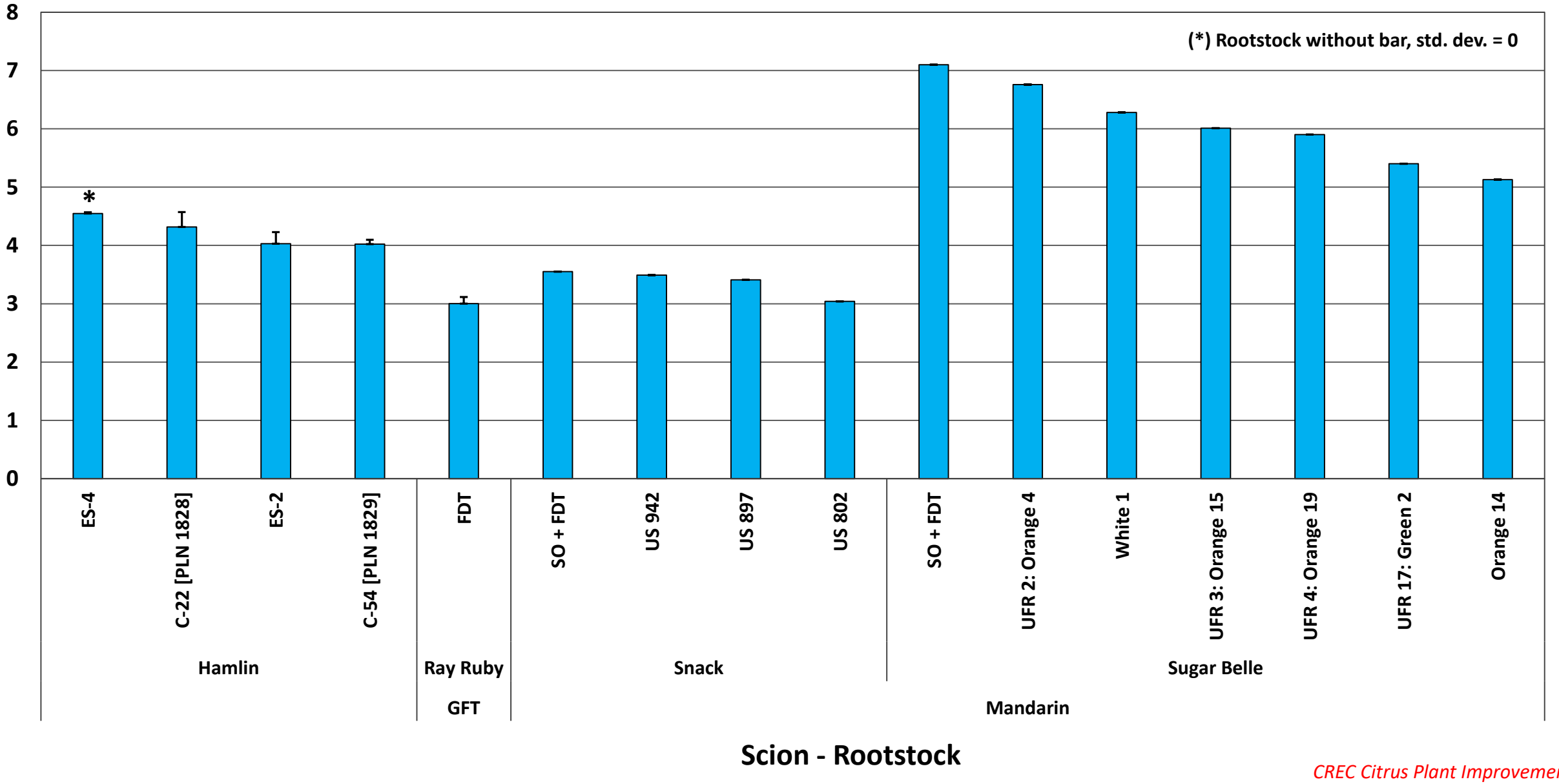

Fig. 13. UF-PSREU scion/rootstock trial – juice Color: mean + std. dev. [January, 2020].

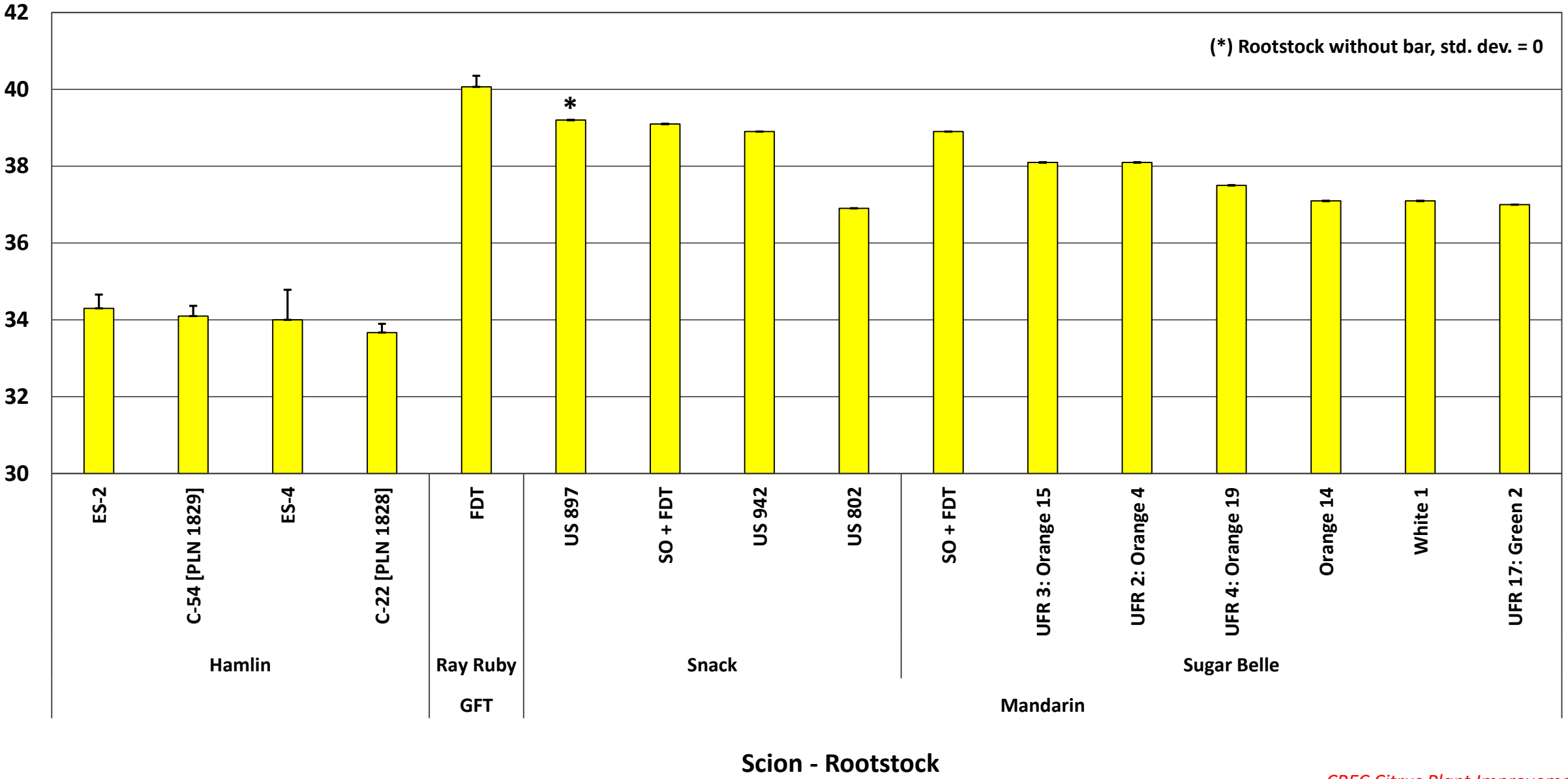

Fig. 14. UF-PSREU scion/rootstock trial – Cumulative yield: mean [boxes/tree, [A]: 3-year seasons 2016/17; 2017/18 & 2019/20 and [B]: 2-year seasons 2016/17 & 2019/20.

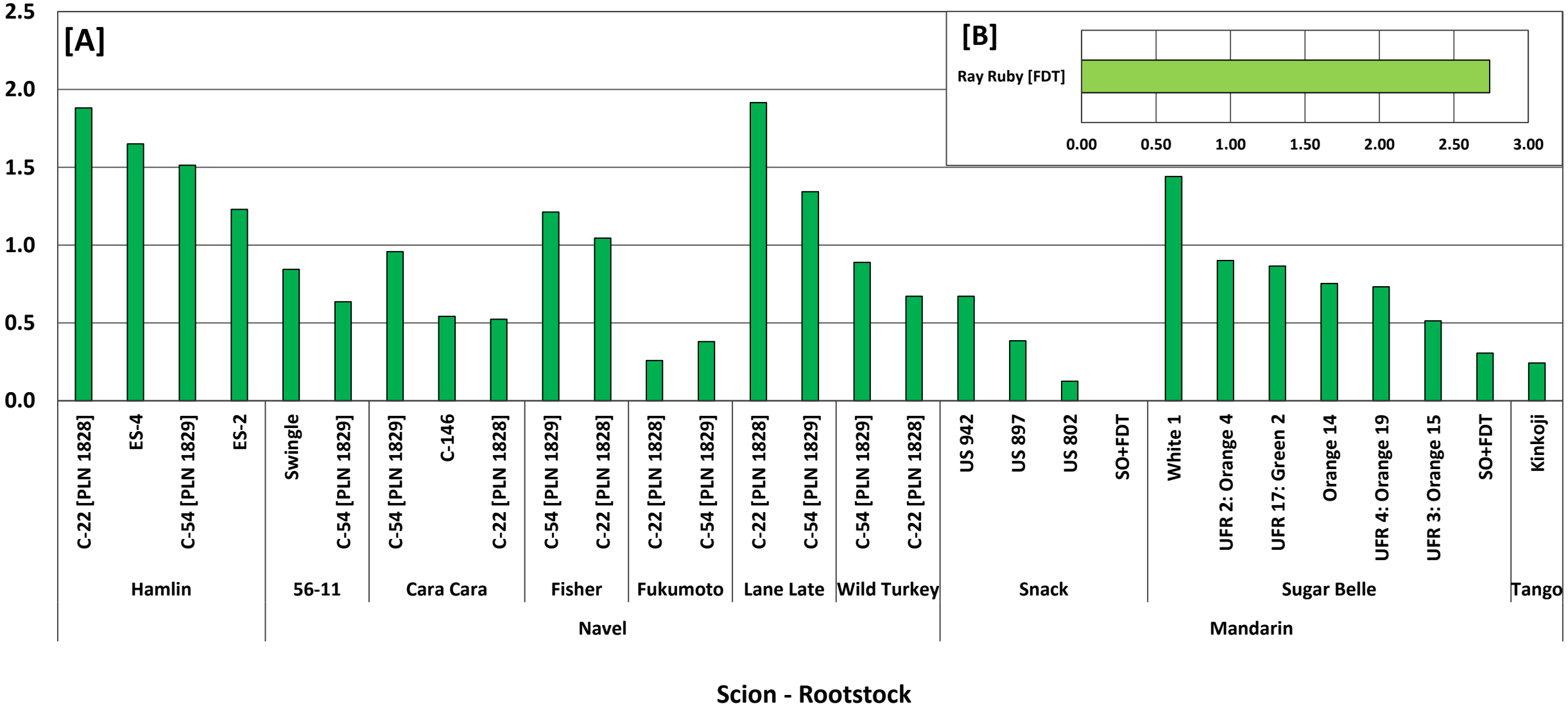

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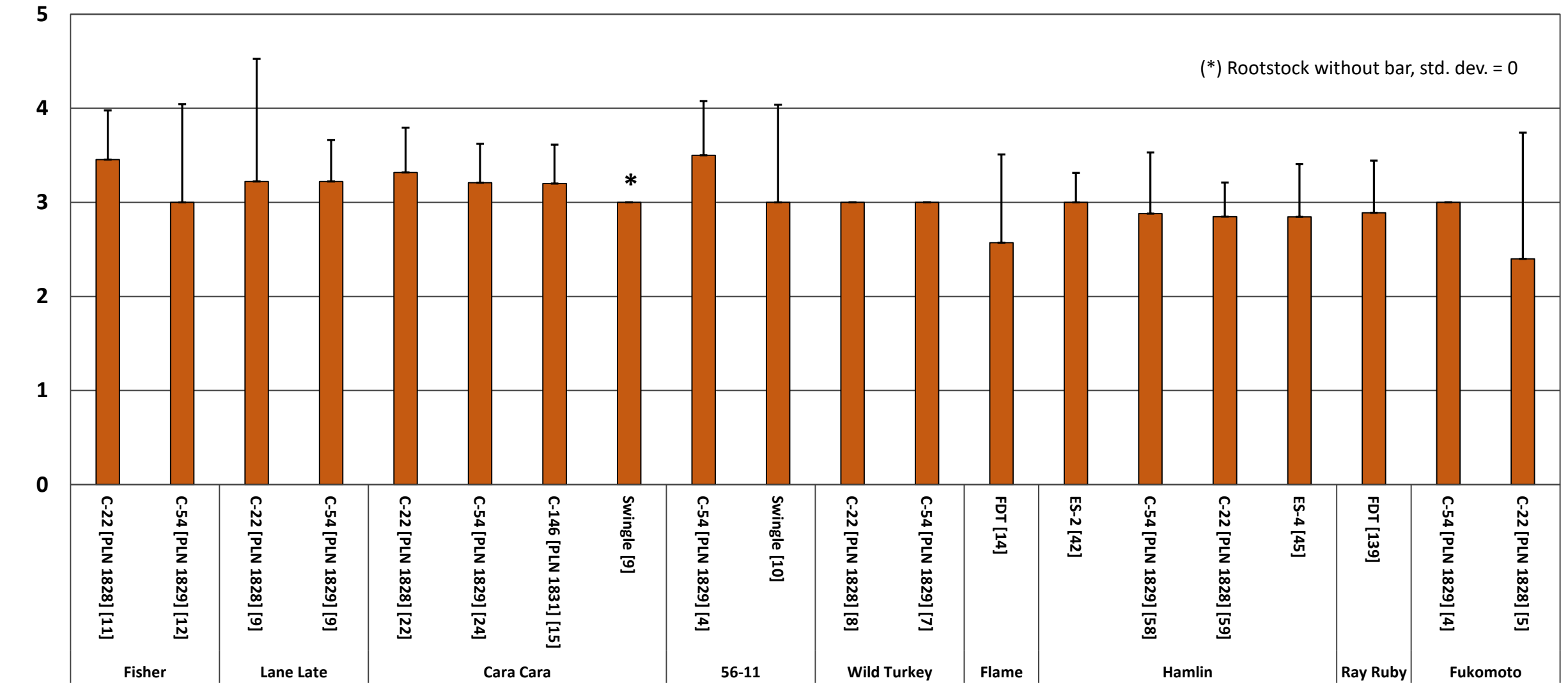
Fig. 15. UF-PSREU scion/rootstock trial – HLB Ratings: mean + std. dev. [November 2020].



HLB Rating
0= dead
1= heavy decline
2= mild decline
3= healthy
4= very healthy

Scion - Rootstock [no. of tress evaluated]

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Navel orange selection/rootstock/HLB study*

Because HLB affects fruit and juice quality, a separate study was initiated in the 2019-20 season to investigate the impact of the disease on navel orange.

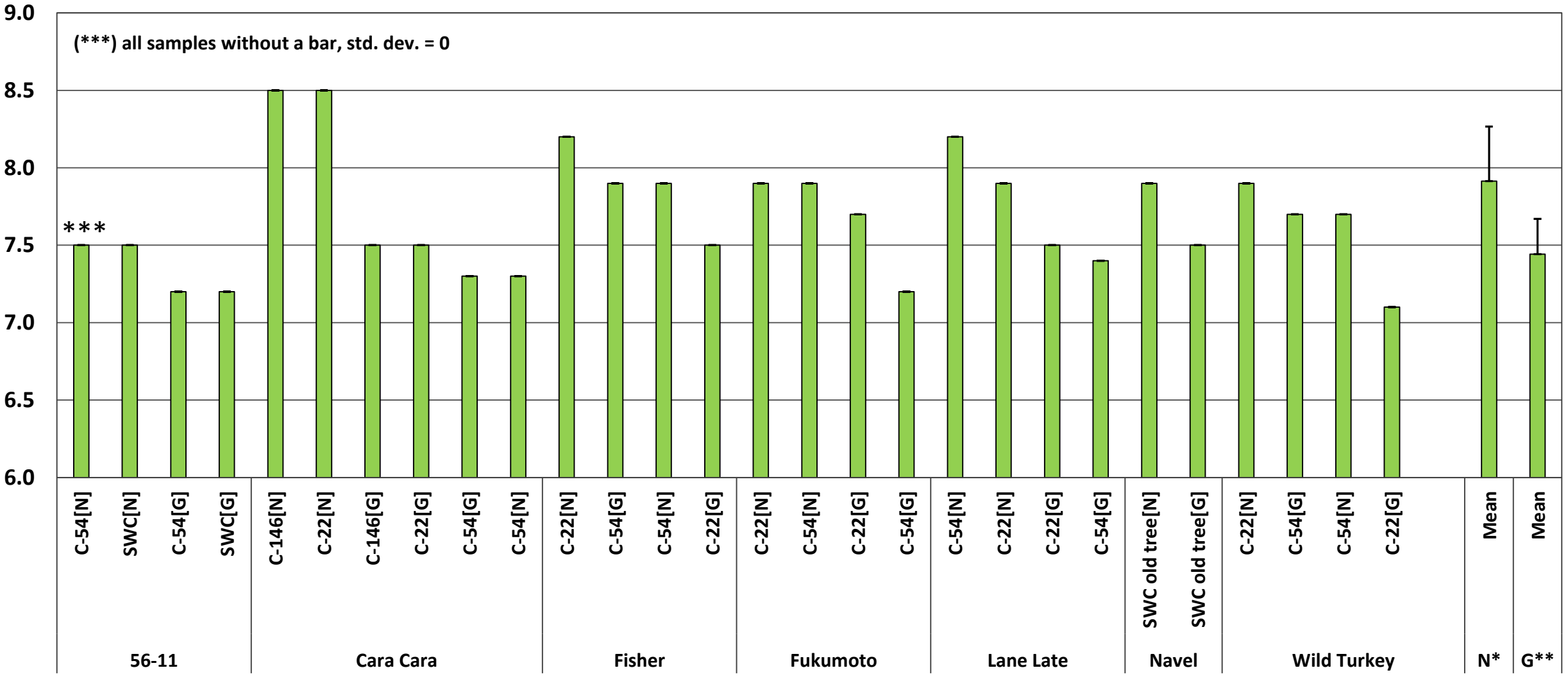
A 50-fruit random sample was collected in mid-December in the same manner and sampling sites as in past years from each scion-rootstock combination and delivered to Dr. Ritenour's lab [Ft. Pierce] where the samples were placed in storage at 50^0F for about 3 weeks.

After storage, the fruit in each sample were divided into two groups according to their size and appearance: [1] N=normal or [2] G=fruit with HLB symptoms. G fruit typically were smaller in size and displayed a peel coloration pattern beginning at stem end of the fruit and progressing towards the stylar end which is the opposite pattern of normal fruit. The juice was extracted from each group and Brix and acid measured.

The results of this preliminary effort are presented in the following slides.

**Investigators: Bill Castle, Pete Spyke, Mark Ritenour*

Fig. 1N. UF-PSREU scion/rootstock trial – Navel scions, Brix: mean [December, 2019].



Scion - Rootstock

(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

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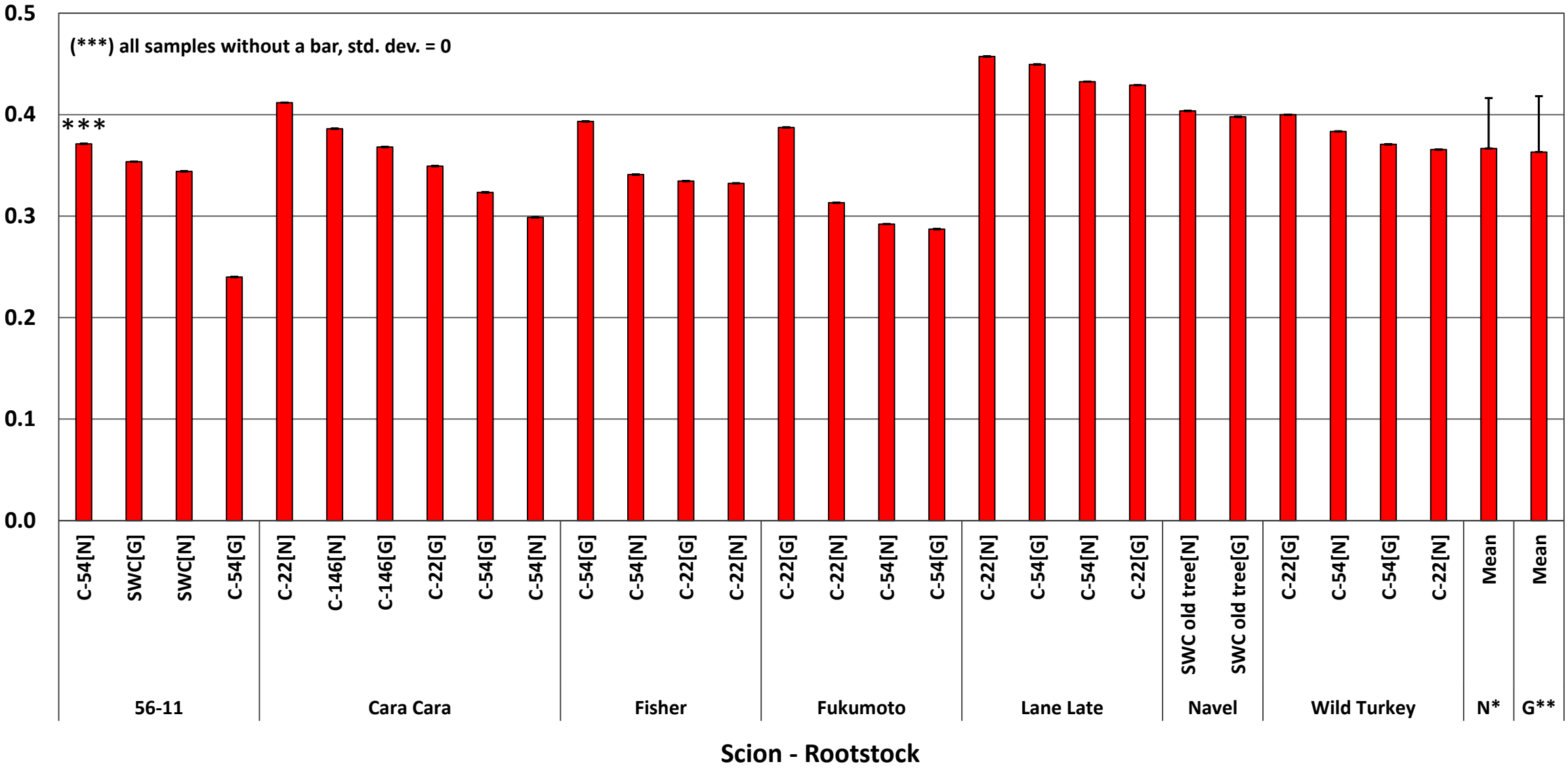
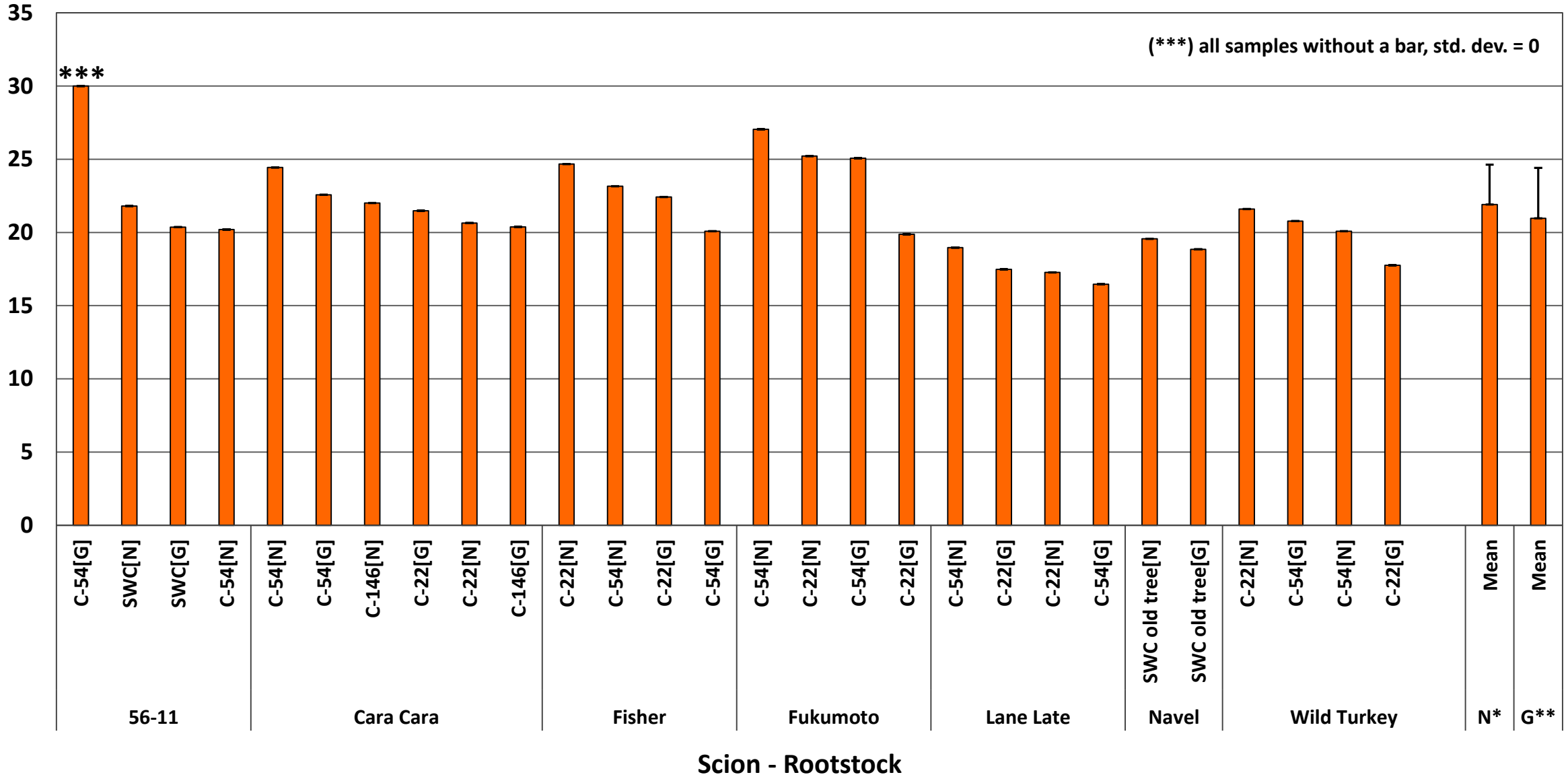
Fig. 2N. UF-PSREU scion/rootstock trial – Navel scions, Acid: mean [December, 2019].



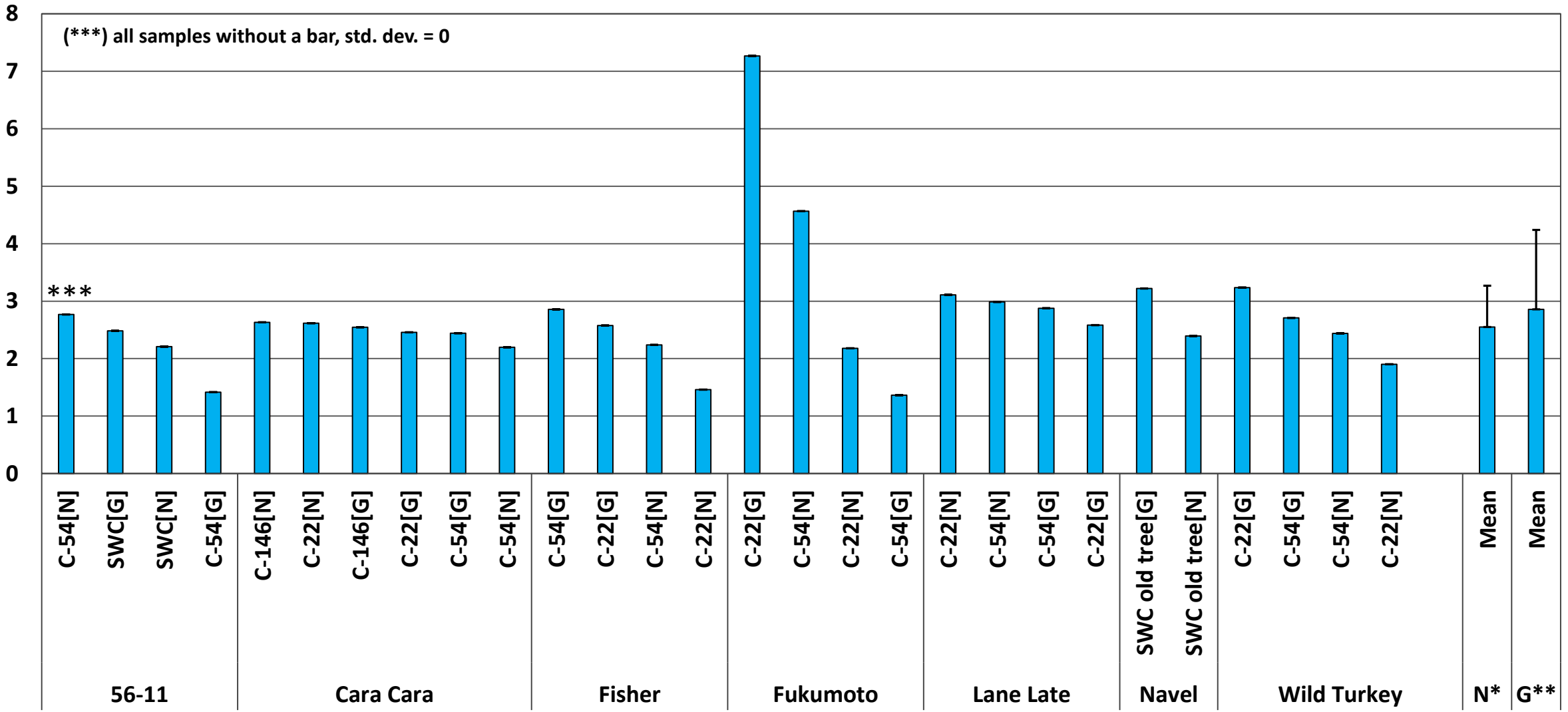
(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Fig. 3N. UF-PSREU scion/rootstock trial – Navel scions, Ratio: mean [December, 2019].



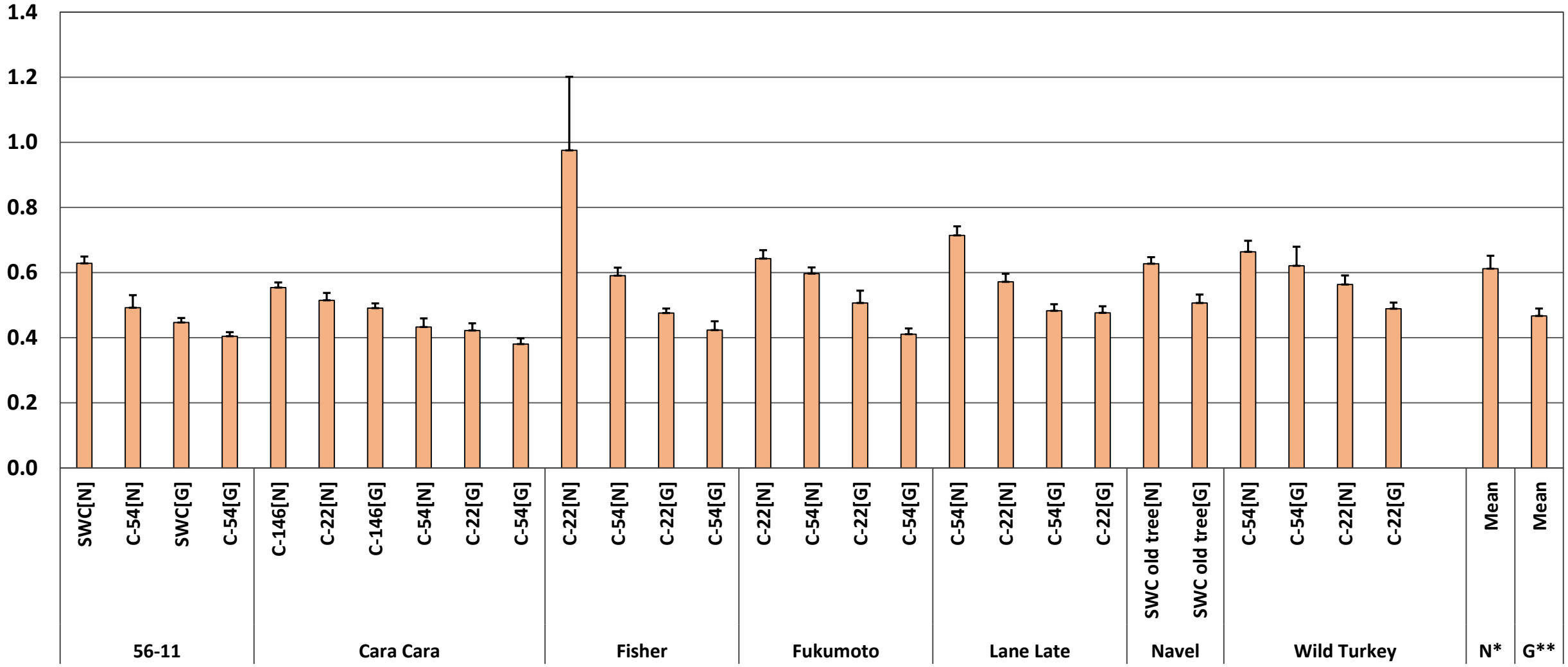
(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Fig. 4N. UF-PSREU scion/rootstock trial – Navel scions, PS/box: mean [December, 2019].



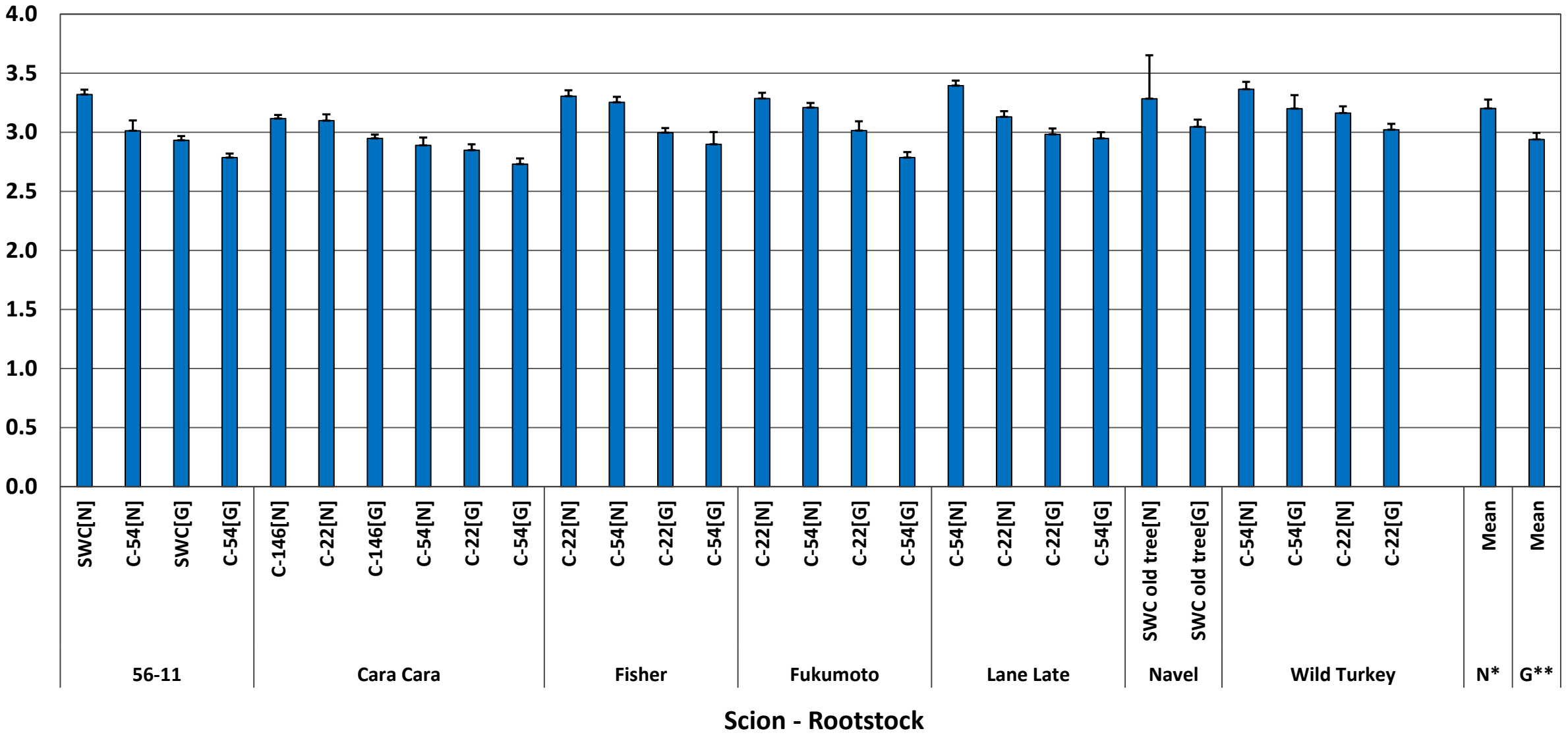
(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Fig. 5N. UF-PSREU scion/rootstock trial – Navel scions, Fruit weight: mean + std. dev. [lbs., December, 2019].



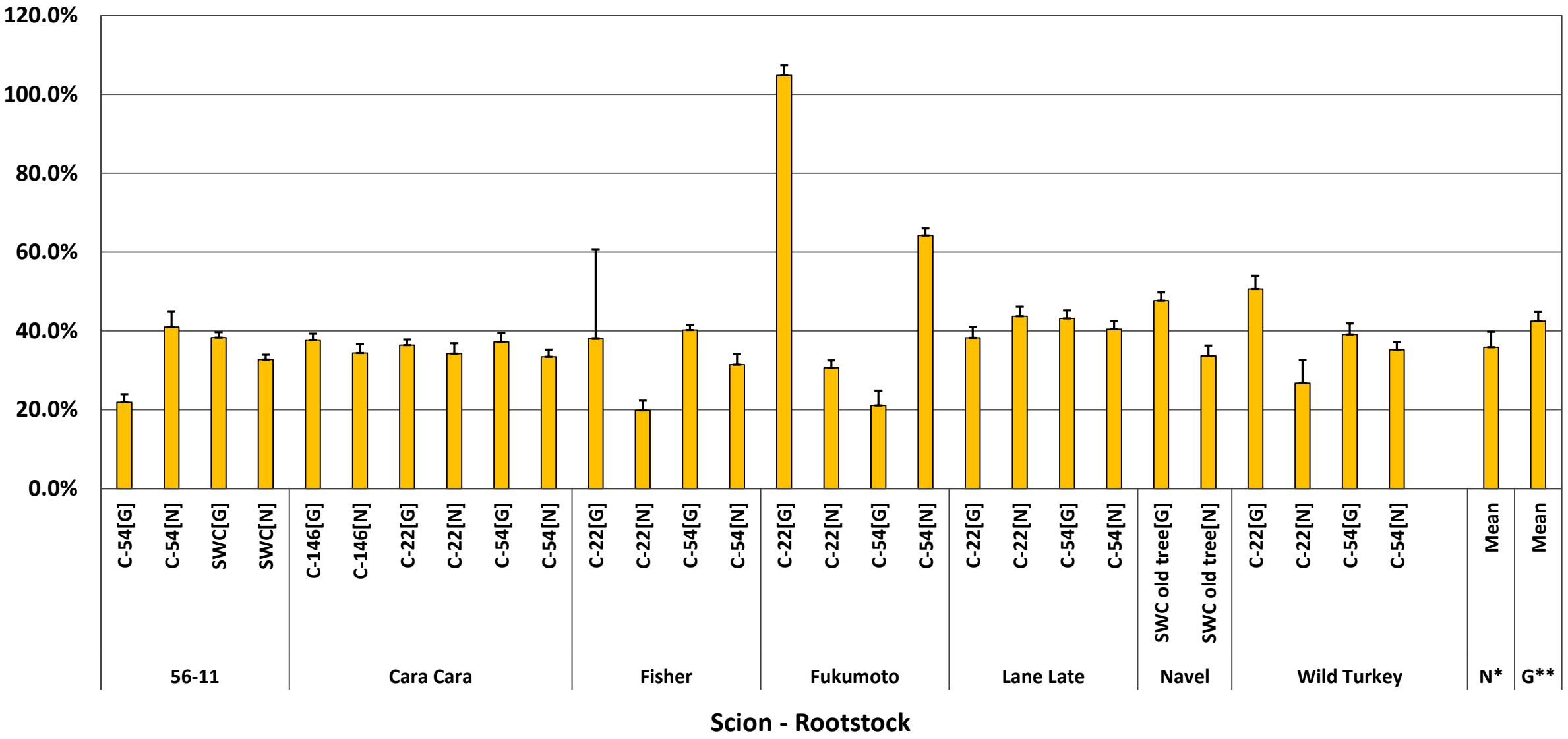
(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Fig. 6N. UF-PSREU scion/rootstock trial – Navel scions, Fruit diameter: mean + std. dev. [inches, December, 2019].



(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Fig. 7N. UF-PSREU scion/rootstock trial – Navel scions, % juice [by weight]: mean + std. dev. [December, 2019].



(*) N= normal healthy fruit; (**) G= fruit with HLB symptoms

Engineering [E]/Technology section

Over-the-row mass harvesting at the UF-PSREU trial and other related technological research

The following slides illustrate the mass harvester in operation at the PSREU trial, primarily with the first prototype machine along with information regarding design features and various improvements planned. A 2nd generation machine is under development as funding becomes available. Other applications are also presented.

Citrus Harvesting and Other Technologies at the PSREU Citrus Grove

Dr. Tom Burks
Agricultural and Biological Eng.
University of Florida

UF UNIVERSITY of FLORIDA
IFAS

Fig. 1E. **Future vision.**

- **Autonomous navigation systems** can improve labor productivity and enhance the performance of many common production tasks; such as, spraying, mowing, tillage and cultivation, scouting, yield estimating and even harvesting.
- **Autonomous robots** can be a viable solution for harvesting fresh market citrus, process market, selective pruning, fruit/leaf sample collection.
- **Robotic systems** can selectively harvest late season Valencia without negative impacts to next year's yield.
- **Automated disease detection** holds promise for the fresh market by eliminating cankerous or blackspot infected fruit from the packing line.
- **Automated in-field disease detection** could provide a more labor efficient and cost-effective approach to scouting for citrus greening, canker, and other diseases.
- New approaches in grove automation offer the potential for **sensor networks to monitor crop status** for a more efficient use of agri-chemicals, water and fertilizers.
- New grove management concepts will offer **improved yield per acre and quicker return on investments** but will demand advanced technologies.

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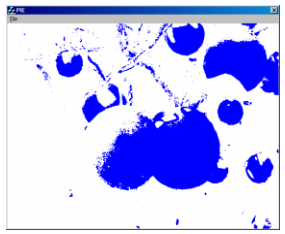
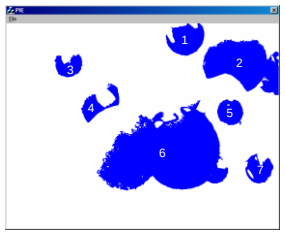
Fig. 2E. **Areas of technology development** [examples follow].

- Fruit detection and mapping
- Harvest path planning
- Linear, non-linear, adaptive/robust visual servo control
- Fruit grippers, and harvesting mechanics
- Harvesting arm concepts
- 3D machine vision canopy reconstruction
- Tree canopy mapping/profiling
- Autonomous vehicle guidance
- Mass harvesting systems development
- Mass harvesting efficiency optimization

Acquired RGB image

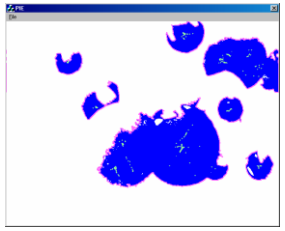


Segmentation

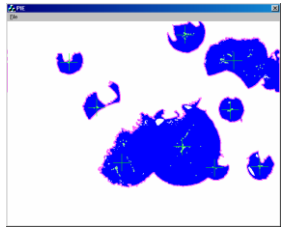


Region Labeling

Perimeter Extraction



Circle detection



Fruit Detection

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Fig. 3E. **Robot servo-control.**

- Integrated fruit detection algorithms with range estimating approach in laboratory.

- Visual servo control of 7 DOF robot arm.

- Locate fruit and drive manipulator to target maintaining fruit in camera field of view.

- Climate controlled field laboratory for performance test.

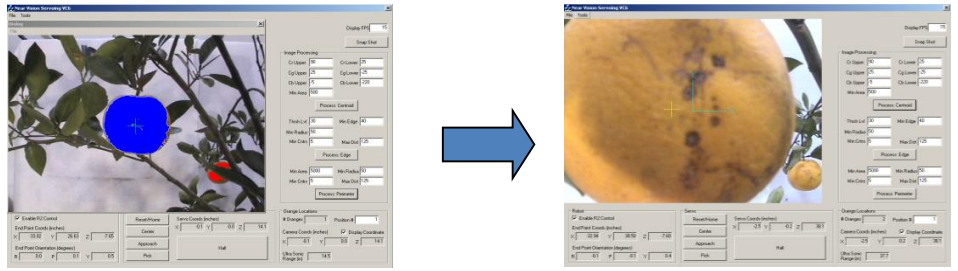

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Fig. 4E. **Harvesting end effector development.**

End Effectors

- Two rigid finger electrical actuators with integrated sensors
- Two revisions of pneumatically actuated with vacuum grip and positive finger grasping

First end effector with force/torque sensor used in harvesting motion testing.

Second prototype with force/torque sensor and integrated camera in hand.

3rd and 4th prototype using pneumatic actuation and vacuum grip.

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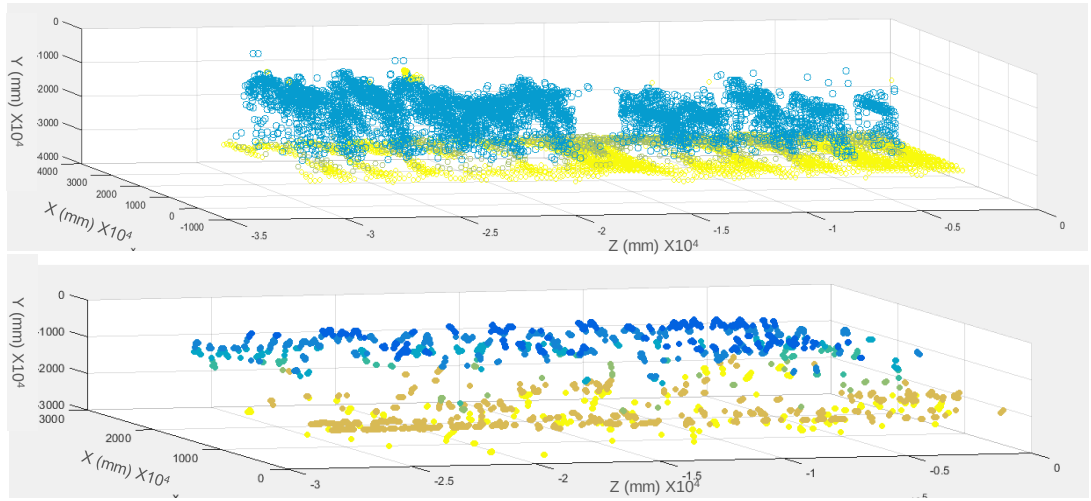
Fig. 5E. **Canopy mapping experiments.**

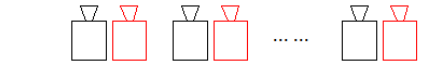
LEDDAR vs UltraSonic Sensor Comparison



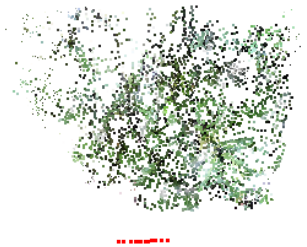
Horizontal setup of the sensor array for outdoor experiments

Leddar (top) and Ultrasonic sensors (bottom)

3D Reconstruction from Multiple Views



Stereo_SFM



Stereo_SFM_Large

Dense Reconstruction

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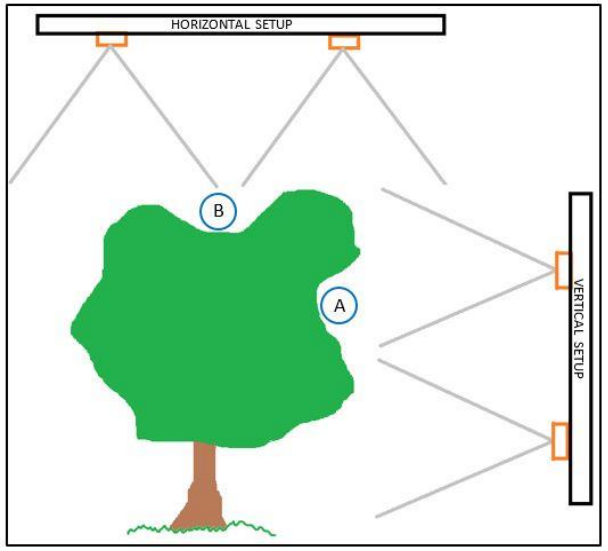
Fig. 6E. **Canopy mapping using Over-the-Top platform.**



Object	Volume estimate for vertical setup (in3)	Volume estimate for horizontal setup (in3)
Box	36135.86	36477.39
Tree 1	37972.40	39504.57
Tree 2	52910.16	54167.36
Tree 3	68391.46	73663.47
Tree 4	31951.42	37847.72
Tree 5	29149.53	31616.94

Applications of technology

- Canopy mapping
- Precision spraying
- Harvesting prediction
- Harvesting optimization
- Canopy management

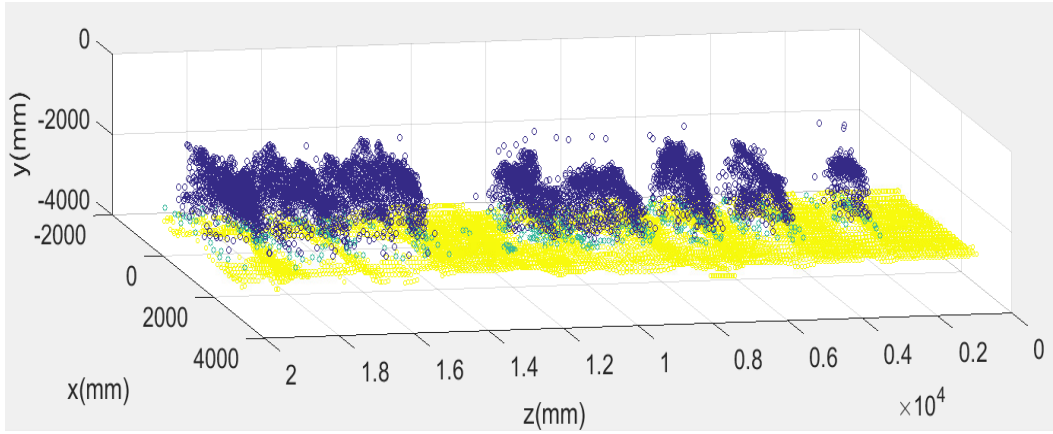
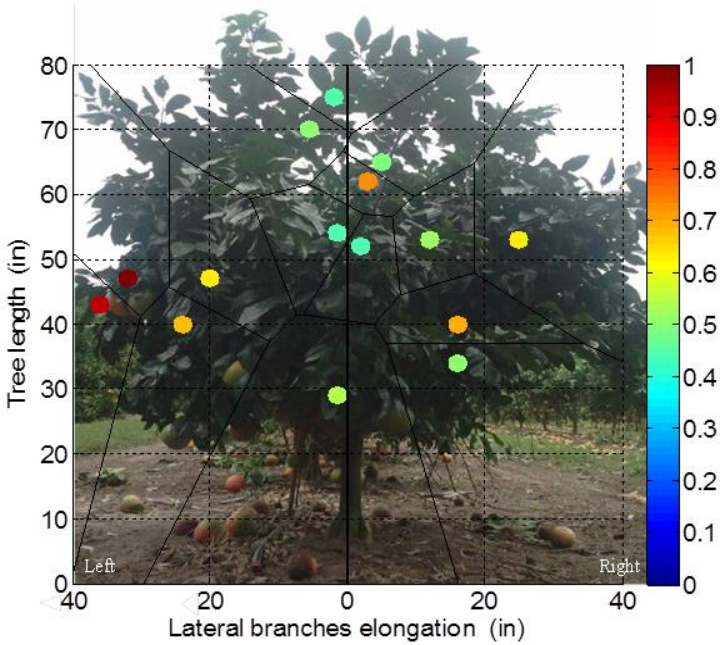


Fig. 7E. **Field deployment and data collection.**

Harvesting Ray Ruby grapefruit on Flying Dragon trifoliate orange rootstock. January, 2014.

Manual fruit pickup and counting.



Shaker acceleration trials.

Maximum acceleration magnitude was 14.09 g, and minimum acceleration was 6.27 g.

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Fig. 8E. **Platform for higher density citrus.**

Prototype I Self Propelled Platform

- Mass harvest testbed

Planned Prototype II Upgrades

- Safety rails & Cab/Control chamber
- Engine power upgrade
- Larger wheels, motors
- Auto-steer, stability and load leveling
- Longer range modifications
  - Dynamic canopy adjustment
  - Catch frame and material handling
  - Selective harvest capability

Chassis under construction for Prototype II.

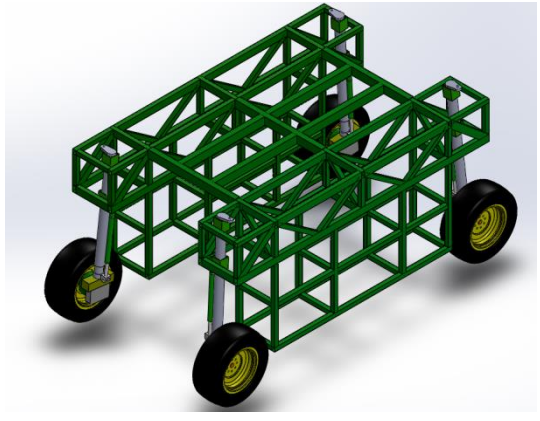

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Fig. 9E. **Grapefruit harvesting trials 2014 at PSREU Block (94% harvest efficiency).**

Note: Catch frame to be added in later prototypes.

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