Citrus Research and Development Foundation, Inc.

Sugar Belle Packing and Processing White Paper
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Estimated Sugar Belle acreage and production

The last 10 years of data from Florida Department of Agriculture and Consumer Services (FDACS) citrus budwood annual reports indicates that 136,134 Sugar Belle trees have been propagated by Florida citrus nurseries.

If one assumes that 95% of the trees are being planted as solid plantings (5% are used as replants) at a planting density of 180 trees per acre (approximate planting density of 10 ft x 24 ft), there would be approximately 718 acres of grove in Sugar Belle in Florida.

FDACS Annual report year	Ranking	# Trees Propagated
2020-21		8,834
2019-20		7,4870
2018-19	In top 30	18,064
2017-18	In top 30	28,904
2016-17	In top 30	42,091
2015-16	In top 30	15,947
5-year cumulative 2011-12 to 2015-16		30,761
10-year total propagations		136,134

Per an email from Mark Hudson with NASS, NASS numbers indicate 130,333 trees on 725.8 acres. Data he provided indicated that last season (2020-21) approximately 21,380 boxes of Sugar Belle were processed, however he did not have data on the number of boxes that were handled in the fresh market.

An estimated annual yield for Sugar Belle would likely be in the range of 113,200 boxes, which would require all acreage greater than 4 years of age to produce around 200 boxes per acre. If those blocks

greater than 6 years of age yielded 300 boxes per acre, and trees 4 and 5 years of age yielded 200 boxes per acre, the total yield would be approximately 130,300 boxes, therefore a potential production range would be between 113,200 and 130,300 boxes. However, it is doubtful that the yield would equal the estimated 130,300 boxes. This estimated yield is based upon speculation and not from an official source.

Please note, NASS does not track or estimate the yield for Sugar Belle, thus a reliable and historical source of production data is not available.

Current production situation of Sugar Belle

Little to no published data is available on the issue of poor peel quality of Sugar Belle, which many growers are reporting. Sugar Belle (LB8-9) is a mandarin hybrid developed by UF/IFAS plant breeders located at the Citrus Research & Education Center and resembles that of 'Minneola' tangelo in shape and appearance. The fruit is mainly intended for the fresh market with a harvest season of mid-November to late December. Published studies have shown that the juice can be blended to improve current citrus juice products. Blended products have received favorable consumer preference ratings of mixes that contain Sugar Belle juice as compared to straight citrus juices.

If production issues with peel weakness can be overcome, Sugar Belle would offer growers a potential solution to enhancing poor Hamlin juice quality by blending the superior color and juice quality of Sugar Belle juice to NFC juice products.

Sugar Belle trees are very vigorous and will require horticultural manipulation to control size and cropping load. It has been noted that in years of heavy cropping, fruit load can be large enough to cause branches to split due to the weight of the fruit. In those 'on' years, fruit size can be quite small, making it difficult to market small fruit in the fresh market and requiring those small fruits to be processed for juice. Sugar Belle trees continue to perform well even in the presence of citrus greening, which is its primary advantage over other mandarin candidates.

Grower comments regarding Sugar Belle:

- Low pound solids and issues of achieving minimum quality standards early in the season.
- Fruit shows typical greening symptoms with smaller fruit showing more symptoms than larger fruit.
- Fruit tends to be soft with peel creasing, and the softness can occur about one month prior to full harvest time.
- Brix of around 10 early in the harvest season normally occurs and improves to 11-12 in January. By late December or early January, the fruit peel becomes soft, creating packing and processing issues at the processing plant.
- Achieving a 13 ratio for the juice is difficult due to high acid levels.
- Fruit size can be small especially on trees with large crops. Large crops can result in limb splitting and breaking due to weight of fruit on limbs.
- One grower commented that even the applications of gibberellic acid (GA) or 2,4-dichlorophenoxyacetic acid (2,4-D) have not had a positive impact on peel softness at his location.

- Higher density plantings have been noted to produce 250 boxes per acre at 4 years of age and around 160 boxes for 3-year-old trees.
- In one block that approaches 20 years of age, the crop is not what was being produced 3-4 years ago.
- In one grove in 2020-21, the grower was able to pack approximately 75% fresh and 25% of the crop was too small to pack fresh. In that same block in 2019-20 crop year, only 20% was packed fresh with lots of fruit being dry, thus not packable.
- It is essential to keep the nutrition in the proper range based upon soil and leaf analysis to achieve a good, packable crop.
- Fresh fruit prices can be in the range of $20 to $25 per box where fruit quality (internal and external) is good.
- It was suggested that the influence of HLB may be a factor in causing soft peel.
- It has been mentioned that growers in North Florida do not seem to be having issues with soft peel, therefore is a contributing factor to soft peel related to environmental factors which might include warmer fall conditions that are common the last two years in Florida?

Packing and processing issues:

- Fruit going to the processing plant must be transported in loads of around 300-350 boxes as fruit damage is likely to occur if the trailer is full due to weight of the fruit on top of the fruit at the bottom of the load.
- When fruit is delivered to the processing plant, it must be run directly to the extractors and cannot be placed in storage bins due to potential fruit damage.
- Fruit tends to be fragile and can be easily damaged by the brush washers and sizers in both packing and processing facilities.
- Acid level runs high which causes the juice to have a lower juice ratio.
- Elimination fruit is usually discounted in price as compared to field run fruit.
- Juice color is excellent, but some have remarked that the juice is like tangerines in flavor.
- Juice has low limonin and high acid level.
- Fruit size can be small, creating processing issue in the extractors.
- After processing Sugar Belle fruit, it requires a full cleanup of the extractors before resuming processing oranges which increases processing costs.

Leaf, peel, and soil analysis

To determine if any nutritional elements were deficient at several locations that were experiencing soft fruit in late December and early January, samples were collected from trees where the crop had not been harvested and those trees having a large crop of small fruit. Standard leaf collection methods were used where approximately 100 leaves from non-fruiting twigs were collected, washed with a gentle dish washing soap, and rinsed multiple times in distilled water. Leaves were then refrigerated and later dried, ground and analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), manganese (Mn), zinc (Zn), copper (Cu), iron (Fe), and boron (B) at Central Florida Soil Laboratory in Bartow, FL. The samples were collected from a rather small area within the block and may not represent the full block if a more random sample was collected.

Fruit and leaves were collected from two field sites to be used for comparison with trees growing in citrus under protective structure (CUPS). Collected fruit was measured for size and peel thickness was measured near the top, side and bottom of the fruit.

Figure 1 shows a typical photo of whole and cut Sugar Belle fruit. From the cut fruit, one can easily see how thin the peel is at or near the bottom of the fruit and contributing to the soft peel issue.

From the peel measurements as shown in Table 1 for 10 randomly selected fruit, measurements from the bottom of the fruit averaged 1.598 mm for Avon Park and 2.056 mm from Ft. Meade as compared to the fruit growing in CUPS with an average peel thickness of 3.033 mm., indicating that the CUPS fruit had thicker peel at the bottom of the fruit which could potentially reduce thin peel issues. The CUPS fruit had a somewhat rougher peel texture than those growing under field conditions. The size of the fruit was also larger in the CUPS as compared to field locations. The CUPS fruit has not been previously noted for having an issue with thin peel. Fruit having a very thin peel in the order of a couple of mm are clearly subject to being soft and creating packing and processing issues when fruit is delivered to the intended market.

Data from leaf analysis (Table 2) indicated nitrogen from all three locations was in the deficient range and highlighted in red. It is not surprising that nitrogen is low as the leaves were collected in the winter. Elements highlighted in yellow were lower than the recommended levels and included P, K, Mg, Ca, and Fe at some locations.

While peel was also analyzed for nutrient levels, no standards are currently published to determine which elements are in any given level. From that data, peel nutritional data was similar for all three locations. However, without standards for comparison, the data has very limited use.

Table 3 indicates that various nutrients will impact external fruit quality. From that table, it clearly shows that K can positively impact peel thickness and was shown to be in the low range for both Avon Park and Ft. Meade locations. Therefore, the growers should consider methods to increase the K levels by either soil and/or foliage applications during the next growing season to potentially increase peel thickness and thereby minimize soft peel issues.

The soil pH at both Avon Park and Ft. Meade was 5.6, as reported by the lab results. Proper soil pH is important as plant nutrient availability is impacted by it. Based on previous studies, the recommended soil pH is 6.0 and both sites could benefit from an application of lime to increase soil pH from the current 5.6 pH level to 6.0. Since both sites have low Cu levels, a target of 6.0 pH is sufficient for citrus production at both sites and the sites would not benefit from a higher soil pH to the 6.5 level.

Potential areas of studies

Since little is currently published on production issues with Sugar Belle, the following are potential areas of investigation:

1) Since only a limited number of growers have plantings of Sugar Belle, in-person visits to multiple plantings could be conducted to determine the full extent of the peel issues. In-person discussions of production practices may lead to strategies in production of higher quality fruit for fresh market.
2) Conduct various studies on the nutritional status in leaves with routine leaf analysis to determine which elements are less than optimal in the peel. It is noted in numerous publications that potassium (K) deficiency reduces fruit number and size and increases fruit creasing; therefore, K levels should be strongly considered for study as well as calcium (Ca), magnesium (Mg), manganese (Mn) and boron (B).
3) Conduct trials utilizing gibberellic acid (GA) and/or 2,4-dichlorophenoxyacetic acid (2,4-D) sprays to determine if these sprays improve peel thickness or minimize soft peel. Any sprays containing GA would need to be concluded by July as to not delay peel color development in the fall. Sprays containing 2,4-D should not be applied too close to harvest as the higher fruit detachment force may be too high causing plugging of the fruit. GA sprays applied prior to bloom may decrease bloom numbers and therefore reduce crop load which would result in the remaining fruit to be larger and may have a thicker peel.
4) Studies should also be conducted where the canopy is reduced by standard hedging and/or topping practices in locations where trees are large enough to benefit reduction of canopy volume. Previous work by Ed Stover indicated severely overcropped Murcott trees that were topped had a mean fruit size increase of 12% and no reduction in yield. However, other trials did not see an increase in fruit size from combined hedging and topping during physiological drop. Murcott trees tend to produce fruit on the end of branches, which is different than Sugar Belle which has a significant amount of fruit in the inner canopy. Thereby, fruit position within the canopy (Figure 2) may limit the quantity of fruit removed by common hedging practices. Topping may offer an option to reduce crop load to increase fruit size but would need to be investigated prior to making a recommendation.
5) Fruit thinning should be considered by either mechanical or chemical means. Not a lot of work has been previously conducted using chemical thinning, thus this may be a difficult task to complete at the present time.
6) Investigate if Sugar Belle would benefit from higher nutritional application rates like Murcott and Orlando tangelo varieties which have a maximum recommended nitrogen rate of 300 lb./acre.

To accomplish this task of improving fruit quality, a call for proposals should be considered to address the stated concerns by growers and processors to determine the cause of soft peel in Sugar Belle. Studies would have to be conducted over multiple years consisting of foliar sprays of GA, 2,4-D and various nutritional elements. These studies may need to have preliminary studies of current practices in the first year and from that data then develop a full set of study objectives to be investigated over multiple years.

Figure 1. Typical photo of Sugar Belle fruit. Note the very thin peel on the lower part of the cut fruit and measures less than 2 mm in thickness which could contribute to soft peel.

Figure 2. Sugar Belle crop load.

Table 1. Sugar Belle measurements in mm for fruit height and fruit width, and peel thickness at top, middle and bottom of fruit.

Avon Park

sample #	fruit height	fruit width	peel near top	peel middle	peel bottom
1	69.39	53.38	6.7	2.4	1.79
2	60.32	62.81	5.2	3.38	1.41
3	59.12	50.96	3.55	2.65	1.36
4	58.02	52.94	3.98	1.98	1.6
5	62.73	54.14	4.69	2.9	1.05
6	55.1	60.13	3.86	2.45	1.18
7	64.04	61.22	4.06	3.16	2.79
8	63.74	57.88	4.47	2.68	2.04
9	50.42	55.2	3.32	1.65	1.33
10	55.6	59	2.75	2.06	1.43
average	59.848	56.766	4.258	2.531	1.598

Ft. Meade

sample #	fruit height	fruit width	peel near top	peel middle	peel bottom
11	64.17	54.5	4.46	4	1.71
12	60.23	51.12	3.53	2.84	2.26
13	62.31	58.44	4.87	3.3	1.89
14	66.42	54.73	4.05	3.61	2.41
15	65.81	56.07	3.68	2.42	2.04
16	65.83	54.17	3.7	2.64	2.1
17	58.84	49.27	3.87	2.58	1.89
18	65.32	57.24	3.77	3.01	2.6
19	75.93	59.01	3.93	2.88	1.82
20	59.35	54.74	4.42	2.67	1.84
average	64.421	54.929	4.028	2.995	2.056

CREC CUPS

sample #	fruit height	fruit width	peel near top	peel middle	peel bottom
21	75.32	72.45	3.66	2.18	2.75
22	85.17	77.34	4.31	3.84	3.74
23	74.1	74.13	4.18	2.87	2.57
24	87.68	76.34	4.83	3.81	2.99
25	69.64	74.57	3.59	2.47	2.06
26	79.63	70.5	4.69	3.73	2.45
27	69.15	69.38	4.67	3.92	3.71
28	74.57	70.8	4.69	3.49	3.85
29	76.73	76.64	4.6	3.02	2.38
30	74.12	75.1	3.67	3.34	3.83
average	76.611	73.725	4.289	3.267	3.033

Table 2. Leaf and peel analysis formatted by Dr. Arnold Schumann into DRIS.

Formatted for DRIS

Sample I.D.	N	P	K	Mg	Ca	S	B	Zn	Mn	Fe	Cu	**Diagnosis**
Bee Ridge SB	2.1	0.11	0.8	0.24	2.9	0.39	70	17	62	53	3	DEFICIENT: Cu<Zn<N LOW: K<Mg<P<Fe<Ca
Ft. Meade SB	1.8	0.13	0.9	0.32	3.7	0.35	112	60	69	53	6	DEFICIENT: N LOW: K<Fe HIGH: B
CREC SB leaf 11/2021	2.1	0.12	1.4	0.37	2.6	0.22	83	16	34	57	25	DEFICIENT: N<Zn LOW: Ca<Fe EXCESS: Cu
Bee Ridge Peel	0.9	0.07	1.1	0.04	0.7	0.07	18	8	14	7	1	DEFICIENT: Mg<Fe<Cu LOW: K
Ft. Meade Peel	0.6	0.07	0.8	0.07	0.8	0.08	18	23	12	8	1	DEFICIENT: Mg<Fe<N< LOW: K<Zn
CREC SB Peel	0.7	0.06	1.2	0.05	0.5	0.04	16	4	3	3	2	DEFICIENT: Fe<Mg<Mn

Table 3. Identifies how each macronutrient and micronutrient impacts fruit quality. The table is from Nutrition of Florida Citrus Trees. Third Edition. UF IFAS. 2020.

Table 4. Specific internal and external fruit quality effects resulting from macronutrient, micronutrient, and irrigation applications to Florida citrus groves (Koo 1988).

Measurement	Macronutrient element					Micronutrient element					Irrigation
	N	P	K	Ca	Mg	Mn	Zn	Cu	Fe	B	
Juice quality											
Juice content	+	o	–	o	o	o	o	o	o	o	+
Soluble solids (SS)	+	o	–	o	+	o	o	o	+	o	–
Acid (A)	+	–	+	o	o	o	o	o	o	o	–
SS/A ratio	–	+	–	o	+	o	o	o	o	o	+
Juice color (red)	+	o	–	?	?	?	?	?	?	?	o
Juice color (yellow)	+	o	–	?	?	?	?	?	?	?	+
Solids/box	+	o	–	o	+	o	o	o	+	o	–
Solids/acre	+	+	+	o	+	o	o	o	o	o	+
External fruit quality											
Size	–	o	+	o	+	o	o	o	o	o	+
Weight	–	o	+	o	+	o	o	o	o	o	+
Green fruit	+	+	+	o	o	o	o	o	?	o	+
Peel thickness	–[1]	–	+	o	–	o	o	o	o	o	–
Peel blemishes											
Wind scar	–	+	o	?	?	?	?	?	?	?	+
Russet	–	–	o	?	o	o	o	o	o	o	o
Creasing	+	o	–	?	?	?	?	?	?	?	o
Plugging	–	o	–	?	?	?	?	?	?	?	–
Scab	+	o	o	?	?	?	?	?	?	?	+
Storage decay											
Stem-end rot	–	o	–	?	?	?	?	?	?	?	–
Green mold	–	o	o	?	?	?	?	?	?	?	+
Sour rot	o	o	o	?	?	?	?	?	?	?	o

Increase (+), Decrease (–), No change (o), No information (?).
[1] Except in young trees where peel may be thicker.