

Strawberry Breeding Program and Future Directions

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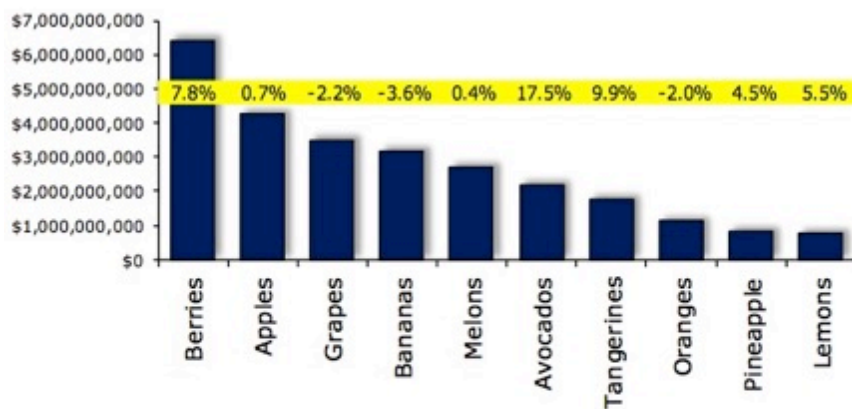
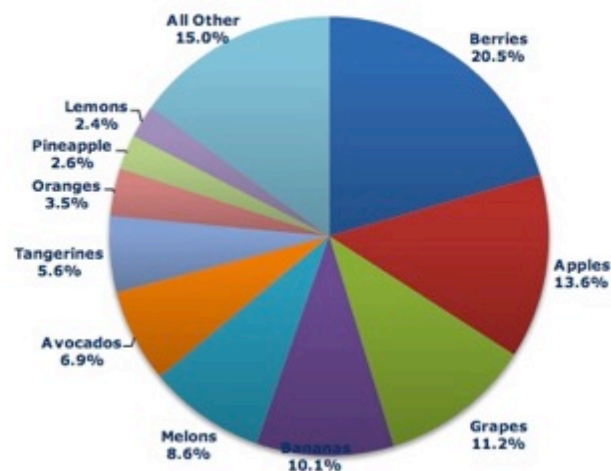
Great Plains Conference

January 12, 2018



Total U.S. Fruit - Dollars

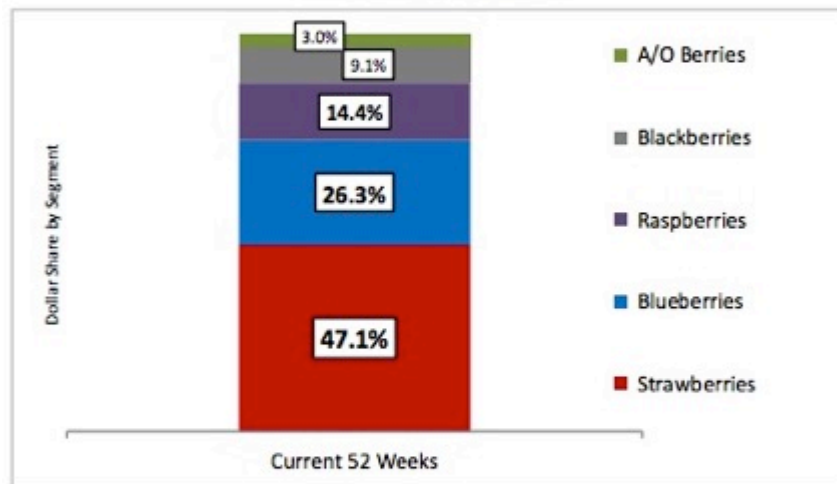
- The berry category accounts for 20.5% of total fruit dollar sales.
- Berries posted a +7.8% increase vs. year ago.



| Dollars | Current 52wks | % Chg |
|--------------------|-------------------------|-------------|
| Berries | \$6,418,558,469 | 7.8% |
| Apples | \$4,241,800,503 | 0.7% |
| Grapes | \$3,489,061,792 | -2.2% |
| Bananas | \$3,165,530,697 | -3.6% |
| Melons | \$2,690,847,557 | 0.4% |
| Avocados | \$2,164,153,248 | 17.5% |
| Tangerines | \$1,747,628,908 | 9.9% |
| Oranges | \$1,095,161,315 | -2.0% |
| Pineapple | \$807,496,174 | 4.5% |
| Lemons | \$750,156,006 | 5.5% |
| Total Fruit | \$31,275,006,710 | 2.6% |

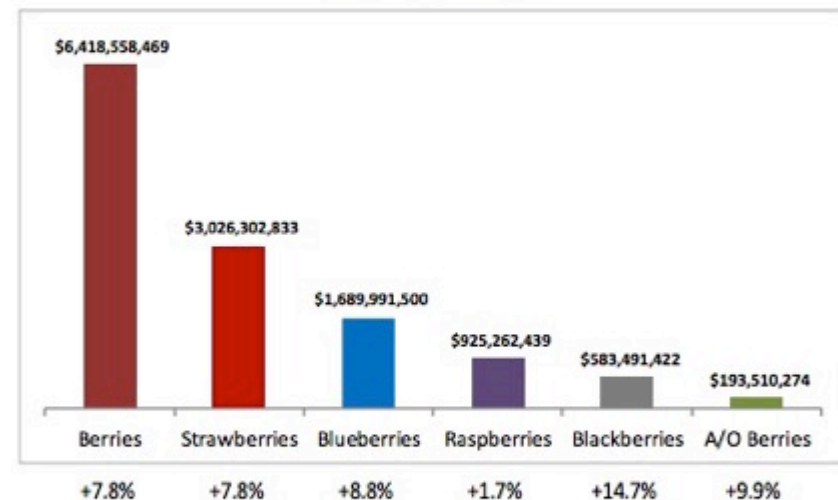
Berries - Dollars

Total U.S.
Berry Category by Segment
Retail Dollar Trends
52 Weeks Ending 7/09/2017



- ♦ Strawberries are the largest segment, accounting for 47.1% of berry dollar sales.
- ♦ Blueberries and raspberries rank 2nd and 3rd, respectively.

Total U.S.
Berry Category by Segment
Retail Dollar Trends
52 Weeks Ending 7/09/2017



- ♦ Berry dollars are up 7.8% versus year ago; strawberry dollars are up 7.8%.
- ♦ Varietal berries are showing sales increases.

Breeding Projects

- Inherited program in 2014
- NC advanced selections and cultivars from other programs
- Update on NCS 10-038 and NCS 10-156
- Anthracnose projects, PhD student, Program
- NCSU Nursery clean up

Tried and True

- Chandler
- Camarosa
- Sweet Charlie

Chandler

- UCD, 1983
- Short day plant, early-mid season
- High yielding variety
- Produces large fruit
- Many culls due to irregular fruit early in season.
- Short shelf life
- Water damage issues due to thin skin
- *Why plant it? Industry standard, widely adapted, known performance*



Camarosa

- UCD, 1993
- Short day
- Mid to late season
- Fruit is larger and firmer than Chandler, good flavor
- Can fruit over an extended period in warmer regions
- Good post harvest traits-can be used for local-market and shipping
- Low yields may be observed in cooler regions or after insufficient degree day accumulation
- *Why plant it? Better post harvest than Chandler*



Sweet Charlie

- UFL, 1994
- Short Day
- 2 weeks of early fruit, then drops off
- Low yield
- Resistant to *C. acutatum* (fruit rot)
- Susceptible to phytophthora
- *Why plant it? 5-7 days earlier than Chandler*



But they are old

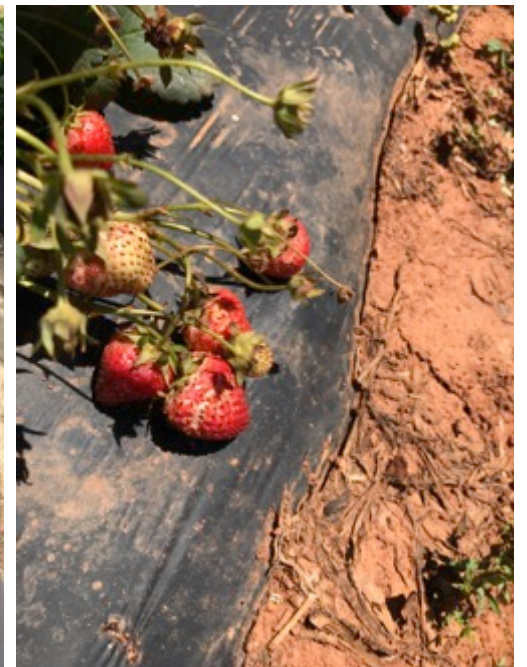
- California and Florida are big but they are focused on other their region
 - UFL breeding program is focused on low chilling
 - UCD breeding program is focused on day neutral (but some short day)
- Private programs
- Need new cultivars!

Background

- 2014, 20 + elite selections
- Replicated trials for 3 years
 - Research station 3 locations
- 2 remaining selections NCS 10-156 and NCS 10-038
- MPRU, virus testing and tissue culture 2014
- On-Farm 2015-16 and 16-17 and -18
- Nursery propagation 2016 one nursery, 2017 others
- Testing material from other programs

2017: A challenging year for strawberries

- Lots of disease
- Rain, one harvest no marketable fruit
- Earliest bloom ever, earliest harvest ever at CCRS
- Warm late winter/early spring. Record???
- Frost event Mid-March



NC STATE

| Genotype | Total Yield (g/ plant) | Total Yield (lbs/A) | Marketable Yield (g/plant) | Marketable Yield (lbs/A) | Percentage Cull (% of total) | Marketable Percent of Chandler | Average berry weight (g) |
|-------------------|---------------------------|------------------------|-------------------------------|-----------------------------|------------------------------------|--------------------------------------|-----------------------------|
| NCS 10-038 | 976 | 36563 | 617 | 23122 | 34.693 | 219.0% | 23.9 |
| Camino Real | 828 | 31027 | 504 | 18871 | 39.177 | 178.8% | 24.1 |
| Sweet Ann | 795 | 29812 | 378 | 14170 | 51.45 | 134.2% | 32.8 |
| Fronteras | 766 | 28701 | 493 | 18460 | 36.689 | 174.9% | 29.6 |
| Winter Dawn | 729 | 27328 | 584 | 21869 | 19.815 | 207.2% | 20.7 |
| Camarosa | 718 | 26892 | 499 | 18710 | 28.791 | 177.2% | 23.1 |
| Winter Star | 716 | 26823 | 597 | 22381 | 16.727 | 212.0% | 24.1 |
| Scarlet | 692 | 25949 | 346 | 12980 | 49.994 | 123.0% | 34.9 |
| Ruby June | 671 | 25153 | 433 | 16230 | 35.172 | 153.7% | 23.9 |
| Sensation | 642 | 24066 | 520 | 19499 | 19.526 | 184.7% | 30.7 |
| Festival | 637 | 23864 | 486 | 18228 | 22.198 | 172.7% | 21.9 |
| Radiance | 623 | 23351 | 555 | 20813 | 10.977 | 197.1% | 26.7 |
| NCS 10-156 | 556 | 20850 | 449 | 16828 | 19.542 | 159.4% | 19.7 |
| Chandler | 483 | 18092 | 282 | 10557 | 41.679 | 100.0% | 20.6 |
| Sweet Charlie | 474 | 17756 | 394 | 14764 | 16.897 | 139.9% | 19.9 |
| San Andreas | 469 | 17579 | 351 | 13171 | 24.967 | 124.8% | 26.7 |
| Pentaluma | 442 | 16549 | 321 | 12035 | 28.274 | 114.0% | 29.7 |
| Lucia | 419 | 15722 | 204 | 7632 | 51.952 | 72.3% | 25.1 |
| I242 | 303 | 11350 | 253 | 9497 | 16.515 | 90.0% | 25.8 |
| Albion | 185 | 6938 | 141 | 5299 | 23.179 | 50.2% | 23.7 |
| NCK 12-184 | 153 | 5745 | 77 | 2870 | 48.738 | 27.2% | 12.9 |
| TUKEY HSD | | 17838 | | 12500 | 20.188 | | 6.6 |

Total yield, marketable yield , percent marketable yield and average berry weight. CCRS 2015 and 2016.

| Genotype | 2015 Total Yield (g/plant) | 2016 Total Yield (g/ plant) | 2 year average Total Yield | 2015 Marketable Yield (g/ plant) | 2016 Marketable Yield (g/ plant) | 2 year average Marketable Yield | 2015 Marketable Percent of Chandler | 2016 Marketable Percent of Chandler | 2 year Marketable Percent of Chandler | 2015 Average berry weight (g) | 2016 Average berry weight (g) | 2 year average Berry Wt |
|---------------|----------------------------------|-----------------------------------|----------------------------------|-------------------------------------------|-------------------------------------------|------------------------------------------|----------------------------------------------|----------------------------------------------|------------------------------------------------|----------------------------------------|----------------------------------------|-------------------------------|
| NC10-038 | 656 | 785 | 720 | 617 | 712 | 664 | 98% | 132% | 115% | 24.3 | 17.5 | 20.9 |
| Camino Real | 547 | 668 | 607 | 505 | 615 | 560 | 80% | 114% | 97% | 25.6 | 21.5 | 23.5 |
| Camarosa | 212 | 668 | 440 | 132 | 607 | 369 | 21% | 113% | 67% | 19.8 | 18.2 | 19.0 |
| Chandler | 733 | 669 | 701 | 632 | 539 | 586 | 100% | 100% | 100% | 20.8 | 19.8 | 20.3 |
| NC10-156 | 547 | 558 | 552 | 495 | 485 | 490 | 78% | 90% | 84% | 20.7 | 14.6 | 17.7 |
| Sweet Ann | 709 | 602 | 656 | 614 | 457 | 536 | 97% | 85% | 91% | 35.7 | 22.4 | 29.1 |
| Merced | 710 | 473 | 592 | 648 | 421 | 535 | 103% | 78% | 90% | 27.3 | 19.6 | 23.4 |
| Sweet Charlie | 244 | 337 | 291 | 219 | 306 | 262 | 35% | 57% | 46% | 17.3 | 14.2 | 15.7 |
| Albion | 277 | 360 | 318 | 254 | 290 | 272 | 40% | 54% | 47% | 27.6 | 20.2 | 23.9 |
| San Andreas | 645 | 374 | 509 | 583 | 269 | 426 | 92% | 50% | 71% | 25.2 | 18.3 | 21.7 |

Other Cultivars

Appearing in order of high to low yield

- **Camino Real:** High yield, nice appearance, good skin, water damage, disease, flavor ok
- **Sweet Ann:** Plants look nice, watery flavor, white shoulders, mishapen fruit, water damage, disease
- **Fronteras:** Firm, looks like it would ship well, fair appearance, good flavor, disease
- **Winter Dawn:** Stringy texture, fruit smaller,
- **Winter Star:** Firm, may work along the coast, too early for most of NC, water damage

Other Cultivars

Appearing in order of high to low yield

- **Ruby June: Nice appearance and flavor, early, culls were lobster claws, disease**
- **Sensation: Firm and shiny, but not great flavor, best of FL so far, few lobster claws, disease, use in a tunnel?**
- **Festival: Rubbery, disease**
- **Radiance: Rubbery, disease, poor plot stand**
- **San Andreas: Firm, not as good as flavor Albion**

Other cultivars lowest yield

- Albion: Low yield, DN, wonderful flavor, we only harvest spring crop (BUT some growers like it)
- NCK 12-184: Not pretty, tested for disease resistance

Sweet Charlie Radiance



NCK 12-184 Pentaluma

Lucia

Sensation



Albion

Festival

Fronteras

Chandler

Winter Star



Scarlet

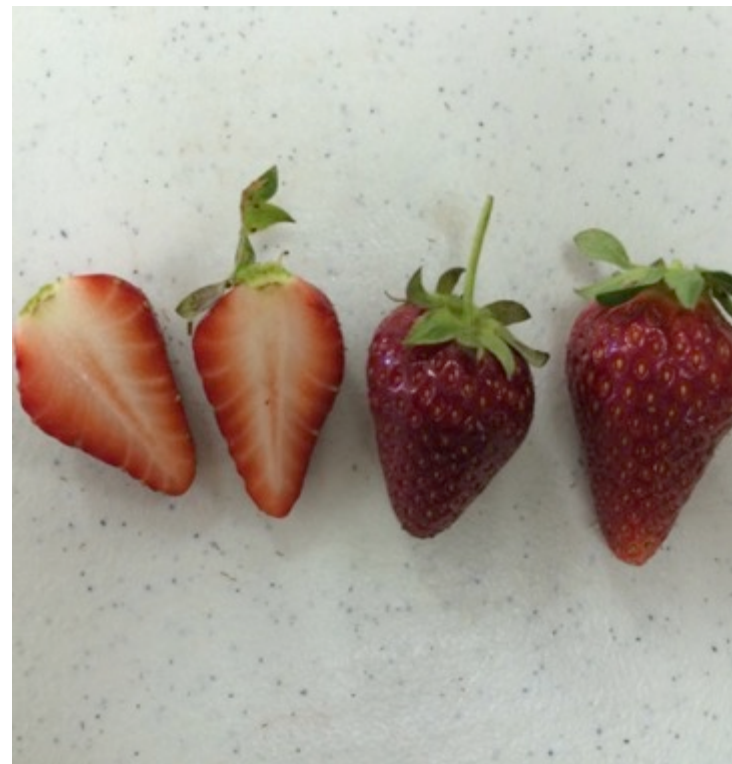
Ruby June

NCS 10-038

What about NCS 10-038 and NCS 10-156?



NCS 10-156



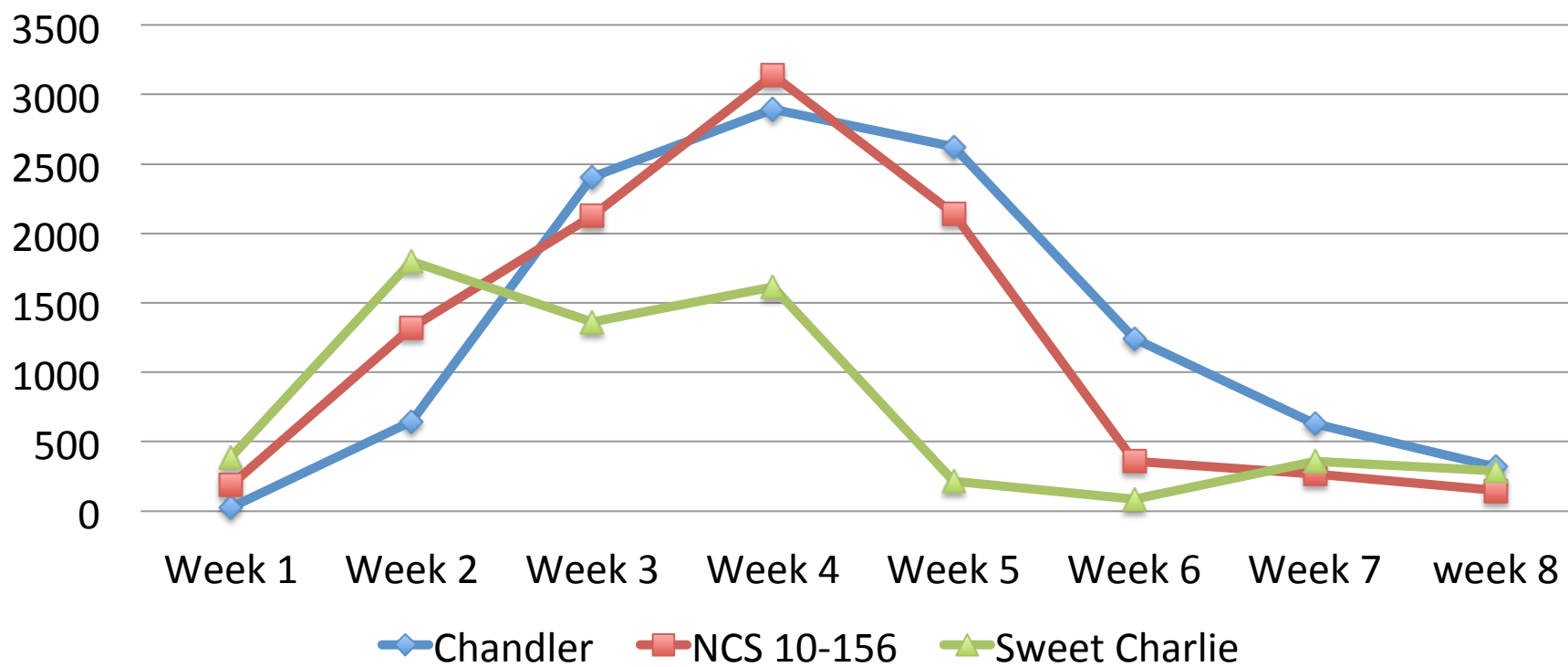
NCS 10-156

- Selected in 2010 PRS
- Early season – short day strawberry
- Very nice appearance
- Uniform conical fruit with red glossy exterior and light interior
- 90 to 116% yield compared to Chandler, higher than SC
- Good fruit size 18 g
- Can be soft like Chandler
- More suitable for local market
- **The one we all like to eat!!!**

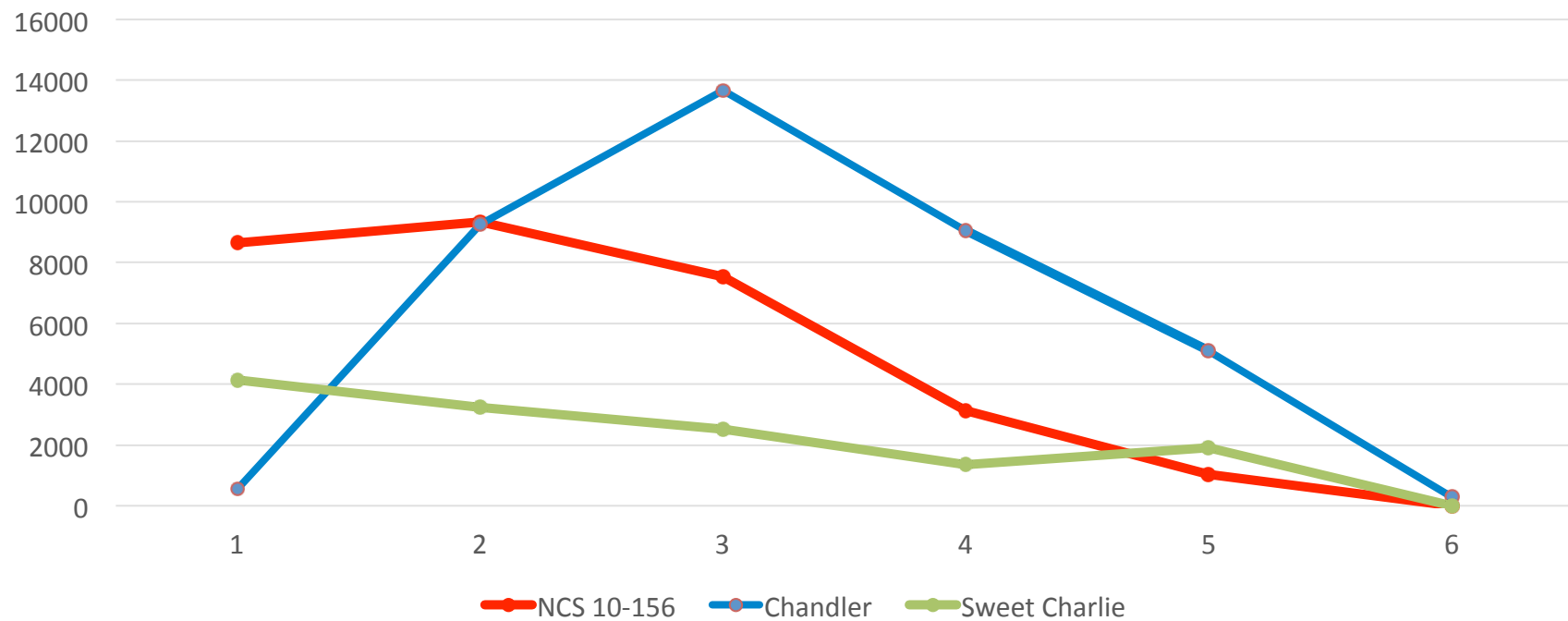
Sweet Charlie v NCS 10-156



CCRS marketable yield 2016 g/plot



Weekly Total Yield CCRS 2015



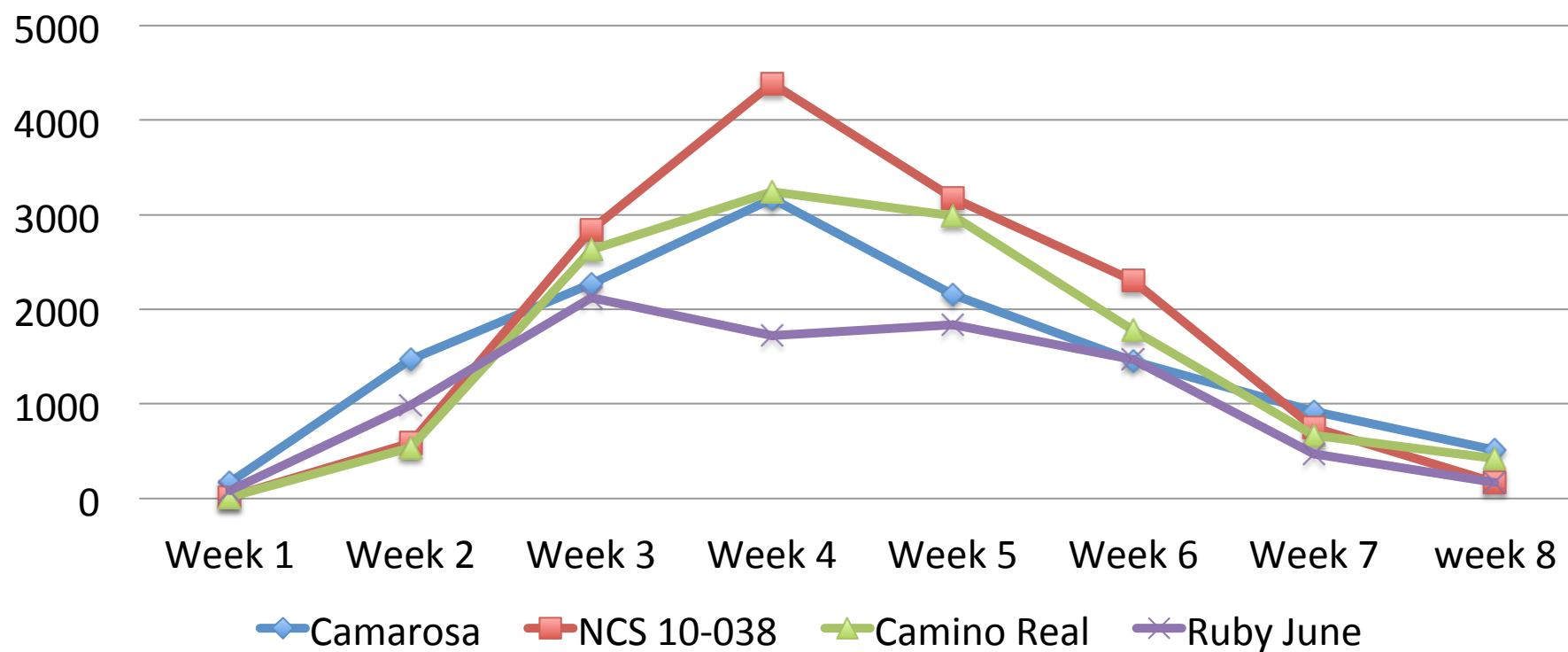
NCS 10-038



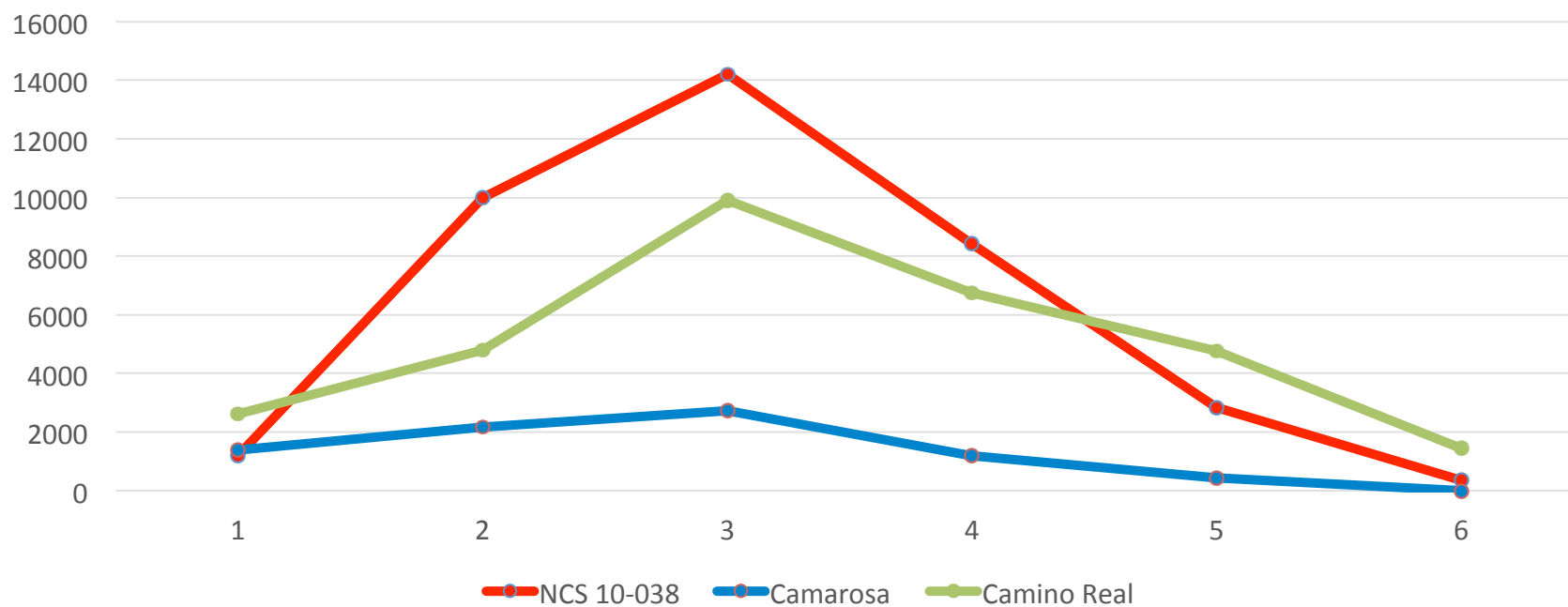
NCS 10-038

- Selected in 2010 at PRS Salisbury NC,
- Late season-short day strawberry
- Uniform blunt conical fruit with firm flesh and light red exterior and interior
- Moderately vigorous plant, open growth habit
- Awesome yield 132 and 153% yield compared to Chandler
- Uniform production through season

Weekly marketable yield CCRS 2016 g/plot



Weekly total yield CCRS 2015



Overall impressions

- NCS 10-156 sweetest, but not firm, best for local markets
- NCS 10-038 quality similar to Camarosa, potential shipper?

Trialing of advanced selections NCS 10-038 and NCS 10-156

- On-farm 2017
 - NC, VA, SC, FL
- On-Farm/Univ/USDA 2018
 - NC, VA, GA, AR, AL, SC, MD



On-Farm Comments 2017

- “038”
 - Nice fruit size and set
 - Orange color
 - Flavor not as good as Camarosa
 - Would try again
 - Yield impressive
 - Post harvest?
- “156”
 - Fruit small
 - Early
 - Seedy
 - Soft
 - Flavor!
 - Try again
 - Local market fruit

What's Next for 038 and 156?

- More testing 2017-18
- Type of farm (156 on PYO)
- Propagation agreements
- Release in 2018
- Name suggestions?

Anthracnose projects

1. Mapping genes for resistance
2. Field screen NCSU germplasm



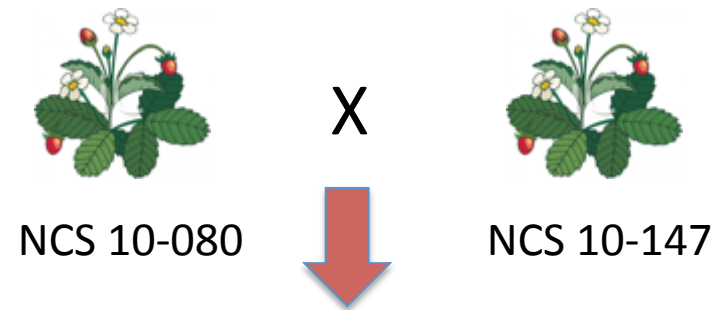
Anthracnose projects: mapping genes

- Jose Guillermo Chacon “Memo”
- PhD student, Fullbright scholar
- Professor in CR prior to NCSU



Anthracnose projects: mapping genes

- Resistance to both C.a. and C.g.
- Susceptible Mom X Resistant Dad
- Seedlings should have range of traits



400 seedlings

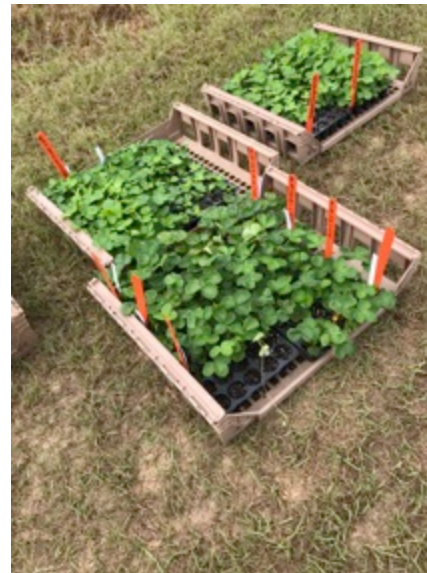
Anthracnose project: Mapping genes

- 400 seedlings
- In vitro, so many duplicates
- Screen for C.a. and C.g. in field and phytotron
- Screening in 2018
 - Field 4000 Cg, 4000 Ca
 - Phytotron 4000 Cg, 4000 Ca



Mapping genes

- DNA extracted from each 400 plant-send to GSL
- Each plant inoculated with C.a. or C.g.
- Each plant scored for disease resistance



Anthracnose projects: mapping genes

- Statistical and genomic tools to identify genes for resistance to both C.a. and C.g.
- Complex!



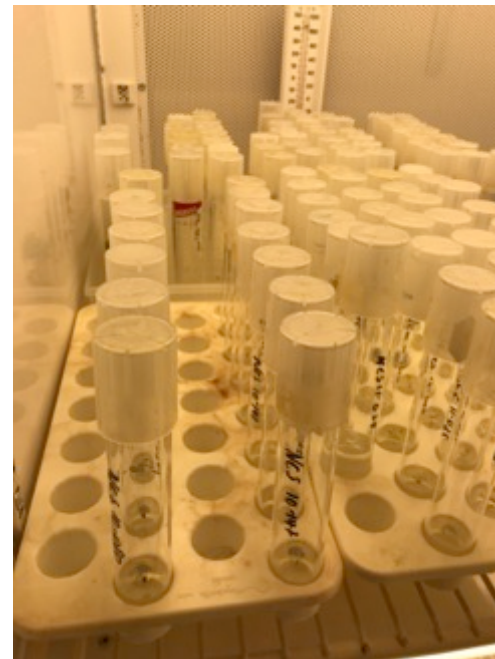
Anthrachnose project: Screening our germplasm in the field

- 2015. NCK material greenhouse screened
- 2015. Field evaluated in location where anthracnose was present
- 2016. Collect yield and other hort data
- 2017. Innoculated plants placed in field
- 2018 summer. Cull plants that are diseased



Nursery clean up

- We have approximately 420 unique NC genotypes
- Disease always a problem in our nursery
- Need to have a back up system
- All nursery material destined for tissue culture as a back up



Thank-you



Rocco Schiavone
Guillermo Chacon
NCDA

