

**Title: Development of New Strawberry Varieties Adapted to the NC Plasticulture System**

**Report**

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**Objective:** To evaluate advanced selections of strawberries from the NC State University strawberry breeding program at research stations and on-farm locations in the Southeastern United States.

**Justification and Description:**

For the past 20 years, three cultivars have been the backbone of the Mid-South and southeastern US strawberry production acreage. Strawberries that are adapted to the states (excluding FL) in the “southern region” have distinct characteristics. They are typically short day plants and require low to moderate chilling hours. ‘Chandler’ released by the University of California (UC) in 1982, is most widely adapted to the range of climates and soils across the southern regions. ‘Chandler’, is a short-day cultivar with consistently high yields, excellent flavor and is a favorite of pick-your-own customers. ‘Camarosa’ was released by UC in 1992. A third cultivar, ‘Sweet Charlie’, a variety from the University of Florida is the cultivar that is most often planted when growers want to establish fruit in early market windows, as it ripens 5-7 days before ‘Chandler’. However, the yield of ‘Sweet Charlie’ is low in comparison to the others.

In recent years, the strawberry breeding program at NC State University has developed a number of advanced lines of strawberry that are uniquely adapted to the climate of the Southeastern US. Data collected since 2015, has indicated that 2 “elite selections” continue to do well. NCS 10-156 is an early genotype that has uniform fruit with excellent flavor, rich red color that has consistently good yields. It is a potential ‘Sweet Charlie’ replacement. It is a bit soft, comparable or better than ‘Sweet Charlie’ or ‘Chandler’. The other promising selection is NCS 10-038. It is a potential ‘Chandler’ replacement with high yields, firmer fruit and its more uniform production across the season than ‘Chandler’.

**Methodologies***Experimental Design and On-farm testing*

Replicated trials were conducted at the Central Crops Research Station (CCRS) in Clayton NC in 2016-17. Plants were set on October 4, 2016. We tested 20 genotypes (numbered selections and named cultivars), including advanced selections from our breeding program and several cultivars from the UC Davis, UFlorida and Lassen Canyon programs.

We harvested fruit from 20 plant plots replicated 3 times. Data was analyzed (ANOVA and Tukey's HSD) using JMP software (JMP PRO 12.2). Total yield (all the berries), marketable yield (berries greater than 10 g and free of noticeable defects), and berry size (based on 25 random marketable berries) was collected over an approximate 6-week period. Data is also presented as a % of marketable yield, and % of Chandler yield (Table1). Data was analyzed using ANOVA, and Tukey MSD (JMP Pro 12.2). The HSD at the bottom of the columns indicates the number that statistically distinguishes yield of one cultivar from the other.

Figures 1 and 2 are close-up shots of NCS 10-038 and NCS 10-156, the two promising NCSU selections.

We also sent at least 100 plants of NCS 10-156 and NCS 10-038 to growers in North Carolina, Virginia and South Carolina. A summary of their comments is in Table 2.

Institutional collaborations included NC A&T University in Greensboro, NC (Sanjun Gu), the USDA Genetic Improvement of Fruits and Vegetable Lab in Beltsville MD (Kim Lewers), and the USDA-ARS in Corvallis OR (Chad Finn). Data from USDA trials is not available, as the plants were not in production in 2017.

At NC A&T, the trials were conducted in tunnels that were managed organically. They were planted on 9/28/2016. The high tunnel was 30' x 96'. Plugs were planted on the side beds in the tunnel (8 beds total), two rows per bed. In-row spacing 12 in inches. Beds were covered with black plastic mulch. Two 12"-drip lines per bed. 1.5 oz/yd<sup>2</sup> row covers were used for frost protection.

## **Results**

Overall, in 2017, the trial at CCRS suffered significant plant loss due to disease and therefore impacted our yield data. However, relative yield of NCS 10-038 and NCS 10-156 was similar to what we had in the past.

NCS 10-038 had the highest total and marketable yield of all the genotypes planted in this year's trial. The percent marketable yield more than twice (219%) that of Chandler. For the past 3 years NCS 10-038 has had the highest yield in all of the trials at the research stations (see previous reports). NCS 10-038 harvest begins slow, peaks mid-season and remains steady in the latter half of the season (Figure 3). Peak fruiting season of NCS 10-038 is comparable to Camarosa, with peak yield occurring in week 4.

The yield of NCS 10-156 is moderate in comparison to the other cultivars in the trial. However, the marketable yield of NCS 10-156 was almost 160% compared to the Chandler. NCS10-156 is considered an early season producer, with early season yields comparable to Sweet Charlie (Figure 4).

A summary of grower feedback is presented in Table 2. In general, the growers preferred NCS 10-038 over NCS 10-156. All of the grower cooperators were primarily wholesale marketers, so they did not like the soft texture of NCS 10-156.

In 2017, seeds of NCS 10-156 were more noticeable than in the past. Seeds were either at or above the surface of the fruit. This trait made the fruit less desirable. We will be trialing several sources of the plants again in 2017-18 to determine if there is an off-type occurring due to the tissue culture process.

Data from NC A&T tunnel and field trials are presented in Tables 3-6. In the high tunnel yields were in general higher than the same genotypes planted in the field. In the tunnel, NCS 10-038 and Fronteras produced the highest marketable yields. NCS 10-156 produced fruit earlier in the field than in the tunnel. Neither NCS 10-156 or NCS 10-038 produced fruit in the winter months in the tunnel.

**Conclusions**

Based on research station and grower feedback, NCS 10-156 was the sweetest, but not firm, best for local markets. We will be testing at smaller farms in 2018. NCS 10-038, had very high yields, with quality similar to Camarosa. Shipping potential appears to be similar to Camarosa.

Both NCS 10-038 and NCS 10-156 had higher yield under tunnels than in the field when grown organically. Neither selection produced fruit in the off-season in the tunnel.

**Impact Statement**

Although we had hoped to release these selections in 2017, we are waiting for another year of feedback from growers. Larger growers want one more look at NCS 10-038 to see if it fits into their schedule. In addition, we want to determine if NCS 10-156 would be a good early season alternative to Sweet Charlie for smaller growers. Finally, we found that tunnel production may improve yield of both selections, but will not change season of ripening.

**References**

NA

**Table 1. Yield data of 20 genotypes tested at the Central Crops Research Station in Clayton NC 2017. NCSU selections in red.**

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)
<b>NCS 10-038</b>	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
<b>NCS 10-156</b>	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
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

**Table 2. Grower comments from On-farm evaluation of NCS 10-038 and NCS 10-156**

NCS 10-038	NCS 10-156
• Nice fruit size and set	• Fruit small
• Orange color	• Early
• Flavor not as good as Camarosa	• Seedy
• Yield impressive	• Soft
• Post harvest unknown	• Flavor a plus, plus
• Would try again	• Would try again
• Nice open canopy	• Might be best for PYO



Figure 1. NCS 10-038, an elite selection from the NCSU strawberry breeding program, with very high yields, moderately firm fruit, with peak production in mid-season.



Figure 2. NCS 10-156, and elite selection from the NCSU strawberry breeding program, with moderate to high yields, excellent flavor and starts producing fruit early in the season.

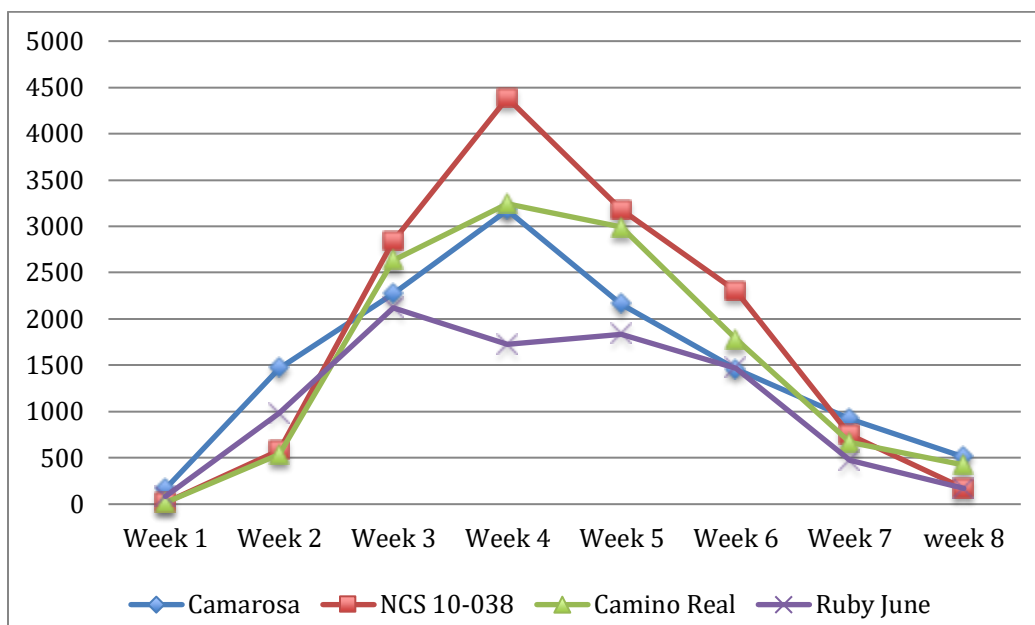


Figure 3. Weekly marketable yield (g/plot) of 4 genotypes grown at the Central Crops Research Station, Clayton NC in 2016.

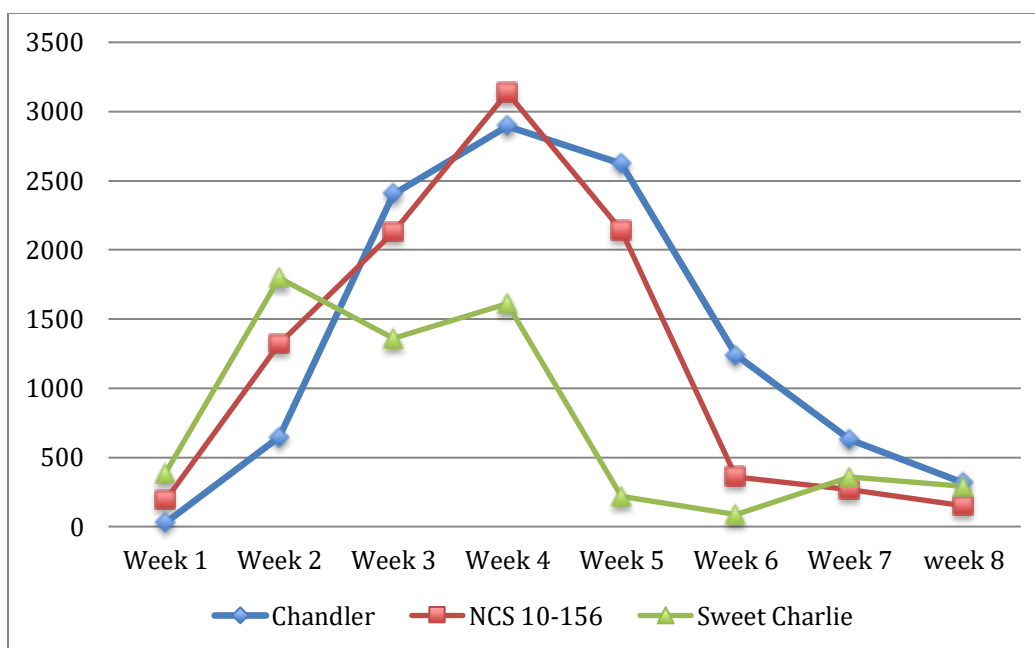


Figure 4. Weekly marketable yield (g/plot) of 3 genotypes of strawberry at the Central Crops Research Station in Clayton, NC in 2016. Note that NCS 10-156 begins to produce fruit earlier than Chandler.

Table 3. June Bearing-2016/17 High Tunnel at NC A&T, Greensboro NC.										
Days after planting (DAP)										
	Marketable Yield gram/plant		Total Yield gram/plant		Marketable Rate (%)		First Harvest DAP		50% Bloom DAP	
<b>NCS10038</b>	702.7	a	1027.1	a	31.7%	d	146.0	ab	144.7	b
<b>Chandler</b>	555.8	b	977.2	ab	43.1%	bc	120.0	b	59.0	d
<b>Fronteras</b>	617.8	ab	966.6	ab	36.0%	cd	104.7	bc	113.0	c
<b>Winter Dawn</b>	455.9	bc	792.0	bc	41.6%	bc	51.0	d	38.7	e
<b>Florida 127</b>	385.4	c	708.0	c	45.6%	b	76.0	cd	61.7	d
<b>NCS10156</b>	398.3	c	701.3	c	43.5%	bc	121.3	b	64.0	d
<b>Flavorfest</b>	208.3	d	450.9	d	53.4%	a	178.0	a	161.7	a
	<0.0001		3E-04		7E-04		8E-04		<0.0001	

Note: Freezing damage made 50% bloom and first harvest date data less coorelated. We removed damaged fruit and flowers so some cultivars took very long to reach 50% flowering (50% plant

Table 4. June Bearing-2016 Field at NCA&T, Greensboro NC.										
	Marketable Yield		Total Yield gram/plant		Marketable Rate (%)		First Harvest DAP		50% Bloom DAP	
<b>Chandler</b>	364.2	a	683.2	a	51.2%	a	130.8	c	68.8	e
<b>Florida 127</b>	222.7	a	478.1	a	54.0%	a	104.0	cd	94.7	d
<b>NCS10156</b>	201.8	a	462.3	a	56.8%	a	137.7	bc	91.0	d
<b>Frontera</b>	203.5	a	414.9	a	52.1%	a	66.0	de	138.7	c
<b>NCS10038</b>	226.1	a	414.5	a	46.7%	a	189.3	a	159.0	b
<b>Flavorfest</b>	175.9	a	405.6	a	56.3%	a	196.7	a	184.0	a
<b>Winter Dawn</b>	156.8	a	390.5	a	60.0%	a	53.7	e	49.0	f
		1		0.291		0.653		<0.0001		<0.0001

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Table 5. High Tunnel Monthly Yield Breakdown, NC A&T Greensboro, NC.																				
	Nov-Dec				Jan-Feb				March				April				May			
	Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield	
Flavorfest	0.0	b	0.0	b	0.0	b	0.0	c	0.0	c	0.3	c	10.0	c	31.9	c	165.9	a	373.5	a
Florida 127	0.0	b	1.3	b	0.6	b	1.4	bc	8.8	a	16.9	a	70.6	b	199.2	ab	142.8	a	259.3	a
Frontera	0.5	b	2.1	b	2.0	a	3.2	bc	0.0	c	0.1	c	57.1	bc	152.3	b	143.9	a	257.2	a
NCS10038	0.0	b	0.0	b	0.0	b	0.0	c	0.2	c	0.2	c	51.7	bc	144.3	b	174.2	a	270.1	a
NCS10156	0.0	b	0.0	b	1.0	ab	6.9	b	4.4	b	11.5	ab	121.9	a	238.2	a	74.6	a	205.6	a
Winter Dawn	15.7	a	20.1	a	0.8	b	15.1	a	0.5	bc	3.4	bc	61.3	b	179.9	ab	78.5	a	171.9	a
		<0.0001		<0.0001		0.018		2E-04		0		0		0		0		0.1		0.2
Table 6. Field monthly yield breakdown NC A&T, Greensboro, NC.																				
Monthly yield	Nov-Dec				Jan-Feb				March				April				May			
	Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield		Marketable Yield		Total Yield	
Flavorfest	0.0	b	0.0	b	0.0	d	0.0	c	1.2	c	4.7	c	106.5	b	207.2	b	100.5	c	238.9	bc
Florida 127	0.8	b	12.4	b	10.6	b	66.9	a	29.1	ab	77.1	a	299.6	a	466.8	a	45.3	c	84.8	d
Frontera	1.2	b	2.0	b	3.8	cd	13.2	c	28.7	ab	43.1	b	369.7	a	585.8	a	214.4	ab	322.5	b
NCS10038	0.0	b	0.0	b	1.5	d	3.6	c	2.8	c	5.1	c	383.0	a	530.9	a	315.5	a	487.5	a
NCS10156	0.0	b	0.0	b	3.2	d	36.7	b	12.8	bc	39.9	b	317.4	a	489.1	a	65.0	c	135.6	c
Winter Dawn	18.6	a	40.4	a	28.7	a	78.8	a	46.7	a	86.7	a	222.1	ab	346.2	ab	139.8	bc	239.9	bc
		0		0.006		<0.0001		<0.0001		0		<0.0001		0		0.1		0		