

Yield, Ear Characteristics, and Consumer Acceptance of Selected White Sweet Corn Varieties in the Southeastern United States

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SUMMARY. White sweet corn (*Zea mays* L.) is widely grown in the southeastern United States. Although 'Silver Queen' has been a popular variety in that region for over 20 years, many other varieties are now available. Selecting a variety for commercial or home production is a complex decision because varieties vary considerably with regard to field performance, ear characteristics, and eating quality. Because limited information is available on overall evaluation of sweet corn varieties, the objectives of this study were to 1) evaluate field performance, ear characteristics and eating quality of selected white sweet corn varieties, 2) globally compare varieties using an overall rank-sum index (ORSI), and 3) determine if 'Silver Queen' is still the best variety or if it benefits from name recognition. Significant differences among varieties were found for

most of the attributes evaluated. When a variety needs to be selected on the basis of a single group of attributes, our results suggest that the best varieties for field performance, ear characteristics and eating quality were 'Even Sweeter' and 'Treasure', 'Silver Queen' and 'Rising Star', and 'Silverado', respectively. When ranks for all attributes were pooled together, the ORSI for all varieties fell within the 40 to 60 median range for ORSI. These results suggest that while marked differences between varieties can be found for a selected attribute, overall all selected varieties showed similar potential for commercial production. Panel response on sweet corn variety names and the rate of correct blind identification of 'Silver Queen' suggested that while it is still among the best varieties, 'Silver Queen' did benefit from name recognition.

Sweet corn is a popular crop among commercial growers and gardeners in the southeastern United States. For 1997, sweet corn production represented in Alabama, Georgia and Florida 1,740, 8,500 and 15,400 ha (4,300, 21,000, and 38,000 acres), respectively (USDA, 1998). Most of the sweet corn grown in Alabama is white and is produced for fresh market. Important sweet corn characteristics for growers are earliness, disease resistance, yield, and ear characteristics. Desirable attributes for consumers are sweetness, texture, and flavor.

Sugar levels in sweet corn kernels are genetically controlled and primarily due to sucrose accumulation. The characteristic creamy texture is due to the accumulation of water-soluble polysaccharides. Sweet corn-like flavor is attributed to the presence of dimethyl sulfide (Swiader et al., 1992). Typically, ranges in sugar levels at harvest (on a dry weight basis) in sugary (su), sugar enhanced (se), and supersweet (sh₂) varieties are 5% to 15%, 8% to 20%, and 25% to 40%, respectively. Supersweet varieties are also referred to as "extrasweet" or "shrunken."

For almost 20 years, the most popular variety of white sweet corn has been the su-type 'Silver Queen'. 'Silver Queen' popularity comes not only from its large well-shaped ears, white kernels, and sweetness, but also from its flavor. Because of the many possible

combinations of genotype and earliness, >100 white sweet corn varieties are now available for commercial production (Simonne et al., 1997). For a grower, selecting the right variety is a complex decision involving considerations of field performance, ear characteristic, and eating quality.

Several studies have compared the field performance of sweet corn varieties (Maynard, 1997; Simonne et al., 1995; 1996; Wong et al., 1994), the chemical composition and changes in sugar content (Garwood et al., 1976; Wann et al., 1971), and the sensory characteristics of sweet corn genotypes (Evensen and Boyer, 1986; Showalter and Miller, 1962). However, field characteristics and eating quality were evaluated in separate studies. In addition, sensory evaluation was performed by a small group of trained panelists or on varieties no longer available. To our knowledge, no recent study has attempted to compare multiple horticultural and sensory characteristics of white sweet corn varieties.

The objectives of this study were to 1) evaluate field performance, ear characteristics, and eating quality of selected white sweet corn varieties, 2) globally compare varieties using an ORSI, and 3) determine if 'Silver Queen' is still the best variety or if it benefits from name recognition, or both.

Materials and methods

SWEET CORN PRODUCTION. Sweet corn variety trials were conducted at the Chilton Area Horticulture Substation (CAHS) in Clanton, Ala., in 1995 and 1996. White sweet corn varieties were preselected for their field performance potential in the southeastern U.S. during trials conducted in 1993 and 1994. 'Silver Queen' and 'Snow Belle' were used as standards. Cultural practices for su, se, and sh₂ types were similar. However, sh₂ varieties were separated by 150 m (300 ft) from the su and se varieties as well as from other field corn plantings to avoid cross-pollination. Two-row plots 7.3 m (20 ft) long and 1.5 m (5 ft) wide were established. Within-row spacing was 20 to 25 cm (6 to 8 inches), creating a stand of ≈60,000 plants/ha (28,000 plants/acre). Planting date was 22 Apr. 1995 and 6 May 1996. Sweet corn was grown following current recommendations. Overhead irrigation was used to supplement rainfall both years and provided

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Fig. 1. Sample data collection form for sensory evaluation.**Sensory Score Sheet for Sweet Corn Varieties**

Date: _____; Male, Female; Age 10–20, 21–30, 31–40, 41–50, 51–60, 61–70, 71–80

1. How many sweet corn varieties do you know? Write the names of all the sweet corn varieties you know.
2. Examine and taste all the corn samples in the plate and rate each of them for appearance, sweetness, flavor, and overall preference on the corresponding lines.

Appearance

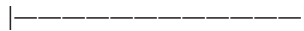
Dislike extremely



Like extremely

Sweetness

Very bland (not sweet)



Very sweet

FlavorVery mild
(no corn-like flavor)Very strong
(corn-like flavor)**Overall preference**

Dislike extremely



Like extremely

3. Which one of the samples do you think is 'Silver Queen'? (write the corresponding number).

≈2.5 cm (1 inch) of water per week. Detailed cultural practices may be found in Simonne et al. (1995, 1996).

FIELD PERFORMANCE AND EAR CHARACTERISTICS. Each variety was harvested when ears reached commercial maturity (Dangler et al., 1992). Harvest dates were between 16 June and 10 July in 1995, and between 11 June and 18 June in 1996. Stand at harvest, average ear set height, shucked ear weight, and ear number were recorded for each plot. Ratings of tip cover, ear fill and eye appeal were made on ten representative ears from each plots using a 1 to 5 scale (1 = very poor; 2 = poor; 3 = fair; 4 = good; and, 5 = excellent). Ear index was calculated as the sum of tip cover, ear fill, and eye appeal ratings.

SENSORY EVALUATION. About 50 representative ears of each variety were selected for the sensory evaluation. On the day of harvest, selected ears were shucked, cut into three pieces, cooked separately in boiling water for 3 min, then cooled in iced water, and placed in a freezer at -20°C (-6°F) until the day of the taste test. Although varieties were harvested on different dates, this procedure allowed all ears to be treated similarly. On the day of the sensory

test, samples were heated in boiling water for 2 min.

Participants of the 1995 and 1996 Fruit and Vegetable Field Day at CAHS on 13 July 1995 and 14 July 1996 were asked to taste and evaluate ears from selected varieties. Both years, the entire sensory test was conducted between 0900 and 1130 HR under natural light. During a seated session in a quiet area, volunteer panelists were first asked to list all of the sweet corn variety names that they knew. The number of answers allowed was not limited. Then, they tasted, evaluated, and rated samples individually for appearance, sweetness, flavor, and overall preference on a 14-cm (5.5-inch), unstructured scale (Fig. 1). Each panelist had a set of five different varieties including 'Silver Queen'. Samples were identified by random three digit numbers. At the end of the test, panelists were asked to identify blindly which sample they believed to be 'Silver Queen'.

STATISTICAL ANALYSES AND RANKING PROCEDURES. All attributes were analyzed separately using Analysis of variance and Duncan's multiple range test ($\alpha = 0.05$) (SAS, 1987). Varieties were then ranked for the three

groups of attribute (field performance, ear characteristics and eating quality). For two-way ties at rank n , ranks n and $n+1$ were replaced by rank $n+1/2$ assigned twice. The next rank was $n+2$. This allows the rank sum of each attribute to always be the same even in the presence of ties [$n+(n+1) = (n+1/2) + (n+1/2)$]. The overall evaluation of varieties was made using ORSI, which was calculated as the sum of the ranks obtain by each variety for each group of attributes. For each attribute, the top variety was assigned the rank of 1. Hence, a lower ORSI corresponded to a better-rated variety.

Results

FIELD PERFORMANCE. The interaction between variety and year was not significant for yield ($p = 0.78$), ear number ($p = 0.41$) and ear set height ($p = 0.46$). Therefore, data for these attributes were combined for both years (Table 1). Variety ($p = 0.05$) and year ($p = 0.01$) significantly affected yield. Mean yields were 14,897 and 8,088 $\text{kg}\cdot\text{ha}^{-1}$ (16,685 and 9,059 lb/acre) for 1995 and 1996, respectively. The top yielding varieties were 'Even Sweeter', 'Treasure', and 'Snow White', all sh_2 types. Because yields

Table 1. Yield, ear number and ear set height of selected white sweet corn varieties.^{z,y}

Variety	Type	Stand ^x (%)	Yield ^w (kg·ha ⁻¹) ^v	Ears ^w (no./ha) ^v	Ear set ht (cm) ^v
Even Sweeter	sh ₂	96	14,726a	65,953a	48bc
Treasure	sh ₂	96	14,264 a	91,356 a	49 b
Snow White	sh ₂	108	12,400 ab	77,561 a	47 bc
Snow Belle	se	110	11,432 ab	74,934 a	47 bc
Fantasia	se	117	11,342 ab	71,775 a	53 b
Starshine	se	104	10,495 ab	65,386 a	39 cd
Silver Queen	su	109	9,180 b	69,163 a	78 a
FMX 413	sh ₂	113	8,925 b	73,907 a	50 b
Silverado	se	114	8,675 b	63,512 a	36 d
Rising Star	se	121	8,291 b	77,850 a	53 b
<i>p</i> variety			0.05	0.63	0.01

^z1995 and 1996 data combined.^yMeans within columns followed by different letters are significantly different (alpha = 0.05) according to Duncan's multiple range test.^x100% stand = 60,000 plants/ha (24,000 plants/acre).^vAdjusted to 100% stand.^w1 kg·ha⁻¹ = 1.12 lb/acre; 1 ha = 2.47 acre; 1 cm = 0.39 inch.**Table 2. Ear characteristics of selected white sweet corn varieties.**^z

Variety	Type	Quality index ^y	Tip cover ^y	Ear fill ^y	Eye appeal ^x
Silver Queen	su	12.8 a	4.0a	4.8 a	4.0 a
Rising Star	se	11.8 ab	3.8 ab	3.8 bc	4.3 a
Even Sweeter	sh ₂	11.6 bc	4.2 a	4.8 a	2.6 d
FMX 413	sh ₂	11.5 bc	2.8 cd	4.5 ab	4.3 a
Starshine	se	11.5 bc	3.0 bcd	4.6 ab	4.0 a
Fantasia	se	11.2 bcd	3.6 abc	3.9 bc	3.8 ab
Silverado	se	10.8 bcd	3.1 bcd	3.9 bc	3.8 ab
Treasure	sh ₂	10.8 bcd	3.5 abc	3.9 bc	3.4 bc
Snow White	sh ₂	10.3 cd	3.6 abc	3.5 c	3.2 c
Snow Belle	se	10.0 d	2.5 d	3.7 c	3.9 ab
<i>p</i> variety		0.01	0.01	0.01	0.01

^zWithin columns, means followed by different letters are significantly different (alpha = 0.05) according to Duncan's multiple range test.^yMean tip cover, ear fill and eye appeal of ten representative ear from each plots on a 1 to 5 scale (1 = very poor; 2 = poor; 3 = fair; 4 = good; and, 5 = excellent).^xEar index calculated as the sum of tip cover, ear fill and eye appeal ratings.

were adjusted to stand, these differences are not due to differences in seeding rates and plant population. These differences may be attributed to larger ears or a higher number of ears per plant.

Differences in the number of ears due to variety ($p = 0.76$) and year ($p = 0.63$) were not significant. Mean ear number for each year or variety was 72,911 ears/ha (29,519 ears/acre). Although variety ($p < 0.01$) and year ($p < 0.01$) significantly affected ear set height, all mean ear set heights were >30 cm (12 inches). This height is often considered as the lowest ear set height acceptable for mechanical harvest. 'Silver Queen' had the highest ear set height and 'Silverado' the lowest.

EAR CHARACTERISTICS. The interaction between variety and year was not significant for quality index ($p = 0.06$), tip cover ($p = 0.27$), ear fill ($p = 0.30$), and eye appeal ($p = 0.10$). Therefore, ear parameters were not separated by year (Table 2). Variety and year significantly affected ear index ($p < 0.01$ for both), tip cover ($p < 0.01$ and 0.46), ear fill ($p < 0.01$ and 0.95), and eye appeal ($p < 0.01$ for both).

Mean ear index, tip cover, ear fill and eye appeal were 10.5 b and 11.5 a, 3.3 a and 3.3 a, 4.1 a and 4.0 a, and 3.1 b and 4.2 a, for 1995 and 1996, respectively. All mean ear characteristics ratings were above the median value of 2.5, suggesting that all the observed differences between varieties were

within the acceptable range. 'Silver Queen' had a significantly higher quality index, while 'Snow Belle' had the lowest.

SENSORY EVALUATION. The numbers of usable answer sheets were 67 and 51 for 1995 and 1996, respectively. Gender distribution was 40 and 27 for male, 27 and 19 for female, and 0 and 5 not reported, for 1995 and 1996, respectively. Age distribution was 6 and 6 for 10 to 20 years old, 8 and 7 for 21 to 30, 16 and 5 for 31 to 40, 10 and 8 for 41 to 50, 12 and 6 for 51 to 60, 10 and 8 for 61 to 70, 6 and 6 for 71 to 80, 6 and 6 for 80 and above, and 0 and 5 not reported, for 1995 and 1996, respectively. The main reasons for discarding an answer sheet were no answer or improper data recording. The most commonly cited varieties were 'Silver Queen', 'Golden Queen' (a yellow variety) and 'Bantam' (another yellow variety). Incorrect responses included "field corn" and "supersweet." Other answers included mixed names or uncommon varieties. These results showed that panelists were not familiar with the many choices available in sweet corn varieties and supported that 'Silver Queen' is still the best-known white sweet corn variety.

Because of significant interactions between year and sensory attributes, data were analyzed by year. For each year, ratings of appearance, sweetness, flavor, and overall preference were significantly ($p < 0.01$) affected by variety (Table 3), while the effect of panelist's age ($p > 0.50$) and gender ($p > 0.50$) were not significant. Since the whole scale was 14 cm long, a rating of 7 cm corresponded to an acceptable median rating. In 1995, all mean scores were >7, except for 'Snow White'. However, in 1996, mean ratings of 'Snow Belle', 'Rising Star', and 'Silver Queen' were <7, indicating these varieties were not acceptable to the panelists. In 1996 also, the highest mean rating of overall preference was for 'Snow White'. Varieties with highest sensory scores were 'Treasure' (in 1995), 'Even Sweeter' (1995), 'Silverado' (1995 and 1996), 'Starshine' (1996), and 'Snow White' (1996).

In 1995, 20 panelists (30% of the entire panel) properly identified 'Silver Queen', 39 (58%), did not and 8 (12%) did not give any answer. In 1996, out of the 117 panelists who participated in the test, only 45 tried to

Table 3. Sensory ratings^z of selected white sweet corn varieties.

Variety	Type	Overall preference	Appearance	Sweetness	Flavor
1995					
Treasure	sh ₂	9.7 a	8.5 abc	9.1 a	8.8 a
Silverado	se	9.4 ab	10.4 a	7.6 bc	8.6 ab
Even Sweeter	sh ₂	8.3 abc	10.1 ab	9.0 a	7.7 abc
Silver Queen	su	7.9 abc	7.3 cd	7.9 ab	7.7 abc
Snow Belle	se	7.5 abc	8.2 abcd	7.7 bc	6.1 c
Fantasia	se	7.3 bc	7.0 cd	8.0 ab	8.8 a
Starshine	se	7.0 c	7.9 bcd	7.4 bc	9.4 a
Snow White	sh ₂	6.0 c	6.1 d	5.6 c	6.3 bc
1996					
Snow White	sh ₂	10.0 a	6.8 b	10.4 a	8.4 ab
Silverado	se	9.4 a	8.2 ab	9.9 ab	9.0 a
Starshine	se	9.2 a	9.0 ab	9.0 abc	7.3 abc
FMX 413	sh ₂	8.1 ab	9.7 a	10.0 ab	6.8 abc
Fantasia	se	8.0 ab	8.6 ab	7.8 bc	7.3 abc
Treasure	sh ₂	7.5 ab	6.7 b	8.3 abc	7.7 ab
Snow Belle	se	6.6 b	6.5 b	7.5 c	8.1 ab
Rising Star	se	6.2 b	7.5 ab	4.9 d	5.1 c
Silver Queen	su	5.6 b	6.7 b	4.2 d	5.8 bc

^zOn a 0 to 14 cm scale (0 = undesirable/dislike; 14 = desirable/like extremely); 14 cm = 5.5 inches.

Table 4. Overall rank sum index^z (ORSI).

Variety	Type	Field ^y 1995-96	Ear quality ^x 1995-96	Sensory ^w 1995	Sensory 1996	ORSI ^t
Even Sweeter	sh ₂	15	12.5	12	---	40
Treasure	sh ₂	8	20	4	8.25	40
FMX 413	sh ₂	17	14.5	---	10	42
Silver Queen	su	15	7	9.5	12.25	44
Fantasia	se	13.5	17	7.5	7.25	45
Rising Star	se	14.5	12.5	---	22	49
Starshine	se	24	13.5	7	5.75	50
Snow White	sh ₂	13.5	23.5	13	4.5	55
Snow Belle	se	15.5	24	9.5	9.5	59
Silverado	se	29	20.5	6.5	4	60

^zORSI calculated by adding the ranks of each attribute (minimum value = 10; maximum value = 90) and adjusted for the number of year of evaluation.

^yField includes yield, ear number, and ear set height ranks.

^xQuality includes tip cover, ear fill, and eye appeal.

^wSensory includes appearance, sweetness, flavor, and overall preference.

^tRounded off.

recognize 'Silver Queen'. Only 10 were correct (22% correct response of attempts, and 5% of the total panelists). Since in either test panelists were presented five varieties, the odds of correctly selecting 'Silver Queen' at random were 20% (1 in 5). These results suggest that indeed very few panelists were able to recognize 'Silver Queen' and that 'Silver Queen' benefits from name recognition rather than from recognition of taste and appearance.

OVERALL RATING. Because each group of attribute was equally important and because year x variety interaction was significant only for sensory

attributes, the ORSI was calculated as ORSI = (2 × field performance ranks) + (2 × ear characteristics ranks) + 1995 sensory ranks + 1996 sensory ranks (Table 4). On a 10 to 90 scale, ORSI ranged between 40 ('Even Sweeter') and 60 ('Silverado'). ORSI for 'Fantasia' was 45 and corresponded to the median value.

Discussion

Significant differences between varieties were found for most of the attributes evaluated. The interaction year × variety was significant only for sensory evaluation. Few attributes had

mean values below an acceptable level, suggesting that all selected varieties were desirable.

Because the three group of attributes selected were of equal importance in variety evaluation, cumulating the ranks allowed to follow a natural tendency of readers of variety trial results, and to see overall which variety was the most desirable. On a 10 to 90 scale, ORSI fell in the 40 to 60 median range. This suggests that overall, all varieties were as desirable. Using a star scale to rate varieties (Simonne et al, 1997), all selected varieties would be rated as "outstanding" varieties. The experimental 'FMX 413' has shown to have attributes as desirable as those of the other varieties.

'Silver Queen' had a significantly higher ear index than all but one of the other entries. However, 'Silver Queen' had a similar ranking for field performance and sensory attributes as most of the other entries. Our results show that panelists were aware of the 'Silver Queen' name, but they could not discriminate between 'Silver Queen' and other entries by taste and appearance alone.

In conclusion, significant differences among varieties were found for most of the characteristics evaluated. When a variety needs to be selected on the basis of a single group of attributes, our results suggest that the best varieties for field performance, ear characteristics and eating quality were 'Even Sweeter' and 'Treasure', 'Silver Queen' and 'Rising Star', and 'Silverado', respectively. When ranks for all attributes were pooled together, ORSI for all varieties fell within the 40 to 60 median range values for ORSI. These results suggest that while marked differences between varieties can be found for selected attributes, overall selected varieties have similar potential for commercial production. Panel response on sweet corn variety names and the rate of correct identification of 'Silver Queen' suggested that while it is still among the best varieties, 'Silver Queen' did benefit from name recognition. Following these results, all selected varieties showed good potential for commercial production in the coastal plain of the southeastern U.S. Earliness, disease resistance and heat tolerance should also be considered together with field performance, ear characteristics and eating quality in selecting a sweet corn variety for commercial production.

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