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Sugar-enhanced and Synergistic Sweet Corn Cultivar Evaluation for Northern Indiana, 2017

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Indiana sweet corn acreage harvested for fresh market averaged 5,233 acres annually from 2013-2015, with a yield of 68 hundredweight per acre (162 crates or 3.4 tons per acre) and an annual value of \$13.4 million (USDA NASS, 2017a). Indiana ranked 16th among states for production of all sweet corn and produced about 0.6% of the nation's total in 2016. The 2012 USDA Ag Census reported 535 Indiana farms producing sweet corn for fresh markets and 69 farms selling to processors (USDA NASS, 2014). Sweet corn fields for fresh market sales are located throughout the state. In northern Indiana, bicolor corn is most commonly grown. Varieties with improved eating quality are of interest to both producers and consumers. Producers are also interested in yield, ear size, appearance, and agronomic characteristics.

This paper reports on six bicolor sugar-enhanced or synergistic sweet corn entries that were evaluated at the Pinney-Purdue Agricultural Center in Wanatah, Indiana.

Materials and Methods

The trial was conducted on a Tracy sandy loam. The fall 2016 soil test showed 1.6% organic matter, pH 6.6, and 73 ppm phosphorus (P), 147 ppm potassium (K), 160 ppm magnesium (Mg), and 600 ppm calcium (Ca). Nitrogen, 40 lb./A N from urea, was broadcast and incorporated on April 12. An additional 60 lb./A N from urea ammonium nitrate solution was injected on June 9.

The trial was set up as a randomized complete block design with three replications. Sweet corn entries were assigned to individual plots one row wide (30 inches) by 30 feet long. Corn was seeded May 16, 2017, with a finger pick-up planter set to drop seeds 10.125 inches apart (20,600 plants per acre). By May 25 more than 50% of emerged seedlings had been eaten in some plots and by May 30 some plots had no remaining plants so we decided to reseed. Plants from the first seeding were removed by hand. For three entries, CSQBF 13-631, CSQBF 14-773, and CSQBF 14-774 there was not enough seed to use in the planter and so seeds were hand-planted in approximately 20 ft. of row using jab-planters. We thought birds had been eating the seedlings and so row cover was pinned to the ground to cover all rows and left in place for 7 days. Black cutworm populations were high during this period and it is likely they caused much of the initial stand reduction. Two guard rows were planted along north and south edges of the experimental area.

Weeds were controlled with atrazine (Atrazine 4L[®]) and s-metolachlor (Dual II Magnum[®]) applied preplant incorporated, cultivation, and hand weeding. Irrigation was applied from an overhead boom on June 12.

Emergence was evaluated 10 days after the second planting (DAP) and final stand determined 14 DAP, on June 13. Plant vigor was evaluated 14 DAP and shortly before harvest. Also shortly before harvest, plant height, and the height from the soil to the middle of the top ear was measured for three plants per plot, and degree of tillering was rated. Each plot was harvested when corn reached marketable stage, which occurred 20 to 24 days after 50% silking. For each plot the weight and number of marketable first ears and number of marketable ears that were

fancy were recorded. Three ears from each plot were selected to evaluate degree of husk cover, husk tightness, degree of tip fill, flag leaf length, overall attractiveness, average ear diameter and length after husking, and shank length. Overall ear quality was also rated. Three people rated the flavor of all entries based on one uncooked ear per taster from each plot. Rating scales are described in table footnotes. Letter ratings for flavor were converted to numerical ratings for statistical analysis.

Quantitative data with equal variance across treatments ($P > .05$) were analyzed using ANOVA followed by mean separation using Fisher's protected least significant difference at $P \leq 0.05$. When one variety showed a variance of 0 for a particular trait, ANOVA was conducted without that variety to achieve equal variances. Regression analyses were used to evaluate correlation between mean responses for each entry and mean days to harvest (DAP); r^2 values for linear regressions significant at $P \leq .05$ are reported.

Results and Discussion

The growing season from May 29 to August 6 was close to normal in temperature and rainfall accumulation: growing degree days (GDD, base 50°F) totaled 1,495, 52 more than normal, and 9.57 inches of rain fell, 0.02 more than normal. Temperatures averaged 1.2°F, -0.3°F, and -3.4°F from normal in June, July, and August, respectively. Rainfall was more than 0.25 inch above normal the last two weeks of May, 1.73 inches below normal in June, 1.26 above normal in July, and about normal during the harvest period in August. Between April 10 and May 28, nearly 8 inches of rain fell, 2 inches more than normal. Soil temperature at 4 inches averaged 69°F the week plots were seeded the second time. (USDA NASS 2017b and MRCC 2017.)

Corn plants in this trial did not grow as vigorously as they usually do. It is possible that nitrogen was insufficient as a result of the high rainfall between preplant nitrogen application in mid-April and seeding at the end of May. The block effect was significant for ear height and late season plant vigor, and the response corresponded to the field gradient from wetter to drier, with the wetter block having ears closer to the ground and lower plant vigor. This is what would be expected if wet conditions reduced nitrogen availability. It is also possible that the second seeding experienced detrimental effects of soil compaction near the planted seed caused by the first seeding.

Emergence of the varieties that were machine-planted on May 30 averaged 84% of the desired stand (20,328) by 10 DAP, and final stand averaged 16,650 plants per acre with no significant differences among varieties (data not shown). Hand-seeded plots had similar emergence and, accounting for the shorter length of row, similar population per acre (data not shown).

Early plant vigor ranged from 3.3 to 7.0 on a scale of 1 (poor) to 9 (excellent) and averaged 4.6 (Table 1). Sweetness and CSQBF 13-631 had significantly greater early vigor than CSQBF 14-773, CSQBF 14-774, My Fair Lady, or Who Gets Kissed. In 2015 Sweetness also had high early vigor, and My Fair Lady and Who Gets Kissed had low early vigor (Maynard and Calsoyas, 2016). Plant vigor ratings near harvest ranged from 2.3 to 6.3 and averaged 5.3 (Table 1). Sweetness had significantly lower vigor near harvest than all others except CSQBF 13-631; other entries did not differ significantly. Both vigor ratings were correlated with maturity: early vigor tended to be higher, and late vigor tended to be lower for earlier-maturing varieties.

Plant height ranged from 4.5 to 6.1 feet and averaged 5.6 feet (Table 1). Who Gets Kissed was the tallest, but My Fair Lady and CSQBF 14-774 weren't significantly shorter. Sweetness was the shortest, nearly a foot shorter than all others.

Tiller ratings ranged from 1.0 to 3.0 on a scale of 1 (no tillers) to 5 (many tillers tall enough to interfere with harvest) and averaged 1.7 (Table 1). CSQBF 14-773 and My Fair Lady consistently received ratings of 1.0 and Sweetness had more tillers, with a rating of 3.0.

Results for yield and ear quality are presented in Table 2. Per acre yields have been calculated by multiplying plot yields by the number of plots per acre and likely overestimate expected yield from field scale production. For hand-seeded lines, a row length of 20 ft. was used. Marketable yield did not differ significantly among entries. Marketable tons per acre averaged 5.9 tons per acre, and ranged from 5.0 to 6.7 and dozens per acre ranged from 992 to 1339 and averaged 1188.

The percentage of marketable ears that were fancy ranged from 14% for My Fair Lady to 87% for CSQBF 14-774 and averaged 52% (data not shown). Differences among entries were highly significant. CSQBF 14-774 and CSQBF 16-631 produced higher percentages of fancy ears than Sweetness and Who Gets Kissed, which were just under 40% and did not differ from each other. All varieties produced higher percentages of fancy ears than My Fair Lady. In 2015 Sweetness produced just under 30% fancy ears (Maynard and Calsoyas, 2016).

Average weight per ear including the shank ranged from 0.63 to 0.95 lb. and averaged 0.83 lb. Differences among entries were highly significant ($P < .0001$). CSQBF 14-774 and CSQBF 16-631 both produced ears averaging over 0.89 lb. and did not differ significantly from one another. As in 2015, Sweetness had the lightest ears. My Fair Lady, Who Gets Kissed, and CSQBF 14-773 produced ears between 0.82 and 0.86 lb. and did not differ significantly from one another or from CSQBF 16-631.

Ear length ranged from 7.2 to 8.0 inches and did not differ significantly among varieties. Diameter ranged from 1.76 inches for Sweetness to 1.97 inches for My Fair Lady. My Fair Lady and Who Gets Kissed were significantly wider than Sweetness. In 2015 also, these two varieties were among the widest, and Sweetness was the narrowest.

Shank length ranged from 3.4 to 7.0 and averaged 4.9 inches. Differences among entries were significant ($P < .001$). Shanks on CSQBF 14-774 averaged 7 inches, significantly longer than all others, followed by CSQBF 13-631 at 5.9 inches. My fair Lady, Who Gets Kissed, and CSQBF 14-773 had shanks from 3.8 to 4.8 inches long. Sweetness had the shortest shanks, 3.4 inches, but not significantly shorter than My Fair Lady.

Ear height from the soil to mid-ear ranged from 12.0 to 25.0 and averaged 20.8 inches. Varieties with ears 22 inches or more above the soil included Who Gets Kissed, CSQBF 14-774, CSQBF 14-773, and My Fair Lady. CSQBF 13-631 had ears significantly closer to the ground than these four (18 inches), and ears of Sweetness were only 12 inches from the ground, significantly lower than all others. In 2015 also, Sweetness had ears the closest to the ground and Who Gets Kissed was among varieties with the highest ears. Days to harvest explained 93% of the variation in ear height, with later varieties producing ears farther off the ground.

Husk cover ratings ranged from 2.8 for Sweetness, indicating less than 3/4 inch of cover, to 5 for CSQBF 14-774, indicating more than 2 inches of cover, but did not differ significantly among

varieties. In 2015 also Sweetness had less than $\frac{3}{4}$ inch of cover on most ears. Husk tightness rating ranged from 1.0 to 2.7 on a 3-point scale but did not differ significantly among varieties.

Tip fill rating ranged from 2.5 to 4.3 and averaged 3.6, with significant differences among varieties. CSQBF 14-774 produced ears filled within $\frac{1}{2}$ -inch of the tip (rating greater than 4), which was significantly better than other varieties except CSQBF 14-773 and Sweetness. My Fair Lady had significantly poorer tip fill than other varieties; its rating of 2.5 indicated between $\frac{1}{2}$ and 1 inch unfilled on most ears.

Overall ear quality rating ranged from 3.7 to 7.3 and averaged 5.6 on a 9-point scale. Varieties separated into two groups: CSQBF 14-774, CSQBF 13-631, and CSQBF 14-773 received ratings greater than 6.5, significantly better than the remaining varieties, which were rated between 3.6 and 4.7.

Flavor ratings by three people ranged from 2.3 to 3.9 on a 5-point scale and averaged 3.2 (Table 1). CSQBF 14-774 and CSQBF 14-773 received the highest ratings and were judged significantly better than My Fair Lady and Who Gets Kissed. In 2015 also, My Fair Lady and Who Gets Kissed received low ratings and Sweetness was in the middle of the range for flavor. There were significant differences among tasters in flavor ratings (data not shown), but there was no significant interaction between taster and cultivar effects on the flavor ratings ($P>0.15$).

Of the two entries harvested on average 67-70 DAP, CSQBF 13-631 had higher quality ears than Sweetness, as indicated by a higher percentage of fancy ears and better ratings for husk cover and overall. Ear length, diameter, and eating quality were similar, but Sweetness had shorter shanks, ears were much closer to the ground, and plants were about a foot shorter. Of the two numbered entries harvested about 78-79 DAP, CSQBF 14-774 tended to have higher quality and ears with much longer shanks than CSQBF 14-773. Plant height, ear height, and flavor ratings were similar for these two. The two organic varieties My Fair Lady and Who Gets Kissed, were harvested on average 77 to 79 DAP. In 2015 emergence was low for these varieties, but this year, with better conditions, emergence and final stands were similar to the variety with treated seed. My Fair Lady produced ears 7.7 inches long and almost 2 inches across with acceptable husk cover, fair tip fill, and medium shanks. Only 14% of the ears were considered fancy. In 2015 My Fair Lady had ears nearly 8 inches long and over 90% were considered fancy; it is possible the lack of vigor this year led to lower quality. Who Gets Kissed produced ears nearly 8 inches long with good husk cover, acceptable tip fill, and medium shanks; just under 40% were considered fancy. This is an open pollinated variety and as a result, harvested ears did not appear uniform and kernel color varied from yellow to white to bicolor. My Fair Lady and Who Gets Kissed were bred for organic production systems.

Evaluation of results presented in Tables 1 and 2, combined with results from other locations and years should aid producers in selecting varieties best suited to their operations. The small number of entries in the trial reflects the growing interest in ‘supersweet’ corn types as opposed to those in this trial with sugar-enhanced and synergistic genetics. A separate trial evaluating supersweet varieties was conducted at the same location, and results are reported in a separate article.

Acknowledgments

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Table 1. Plant vigor, height, tillering, and eating quality of sugar-enhanced and synergistic sweet corn varieties in northern Indiana, 2017.

Cultivar	Vigor ¹		Plant Ht. <i>ft</i>	Tillers ¹	Flavor ²
	<i>Early</i>	<i>Harvest</i>			
Sweetness	7.0	2.3	4.5	3.0	3.3
CSQBF 13-631	6.7	4.3	5.5	1.7	3.2
CSQBF 14-773	3.7	6.3	5.6	1.3	3.9
CSQBF 14-774	3.3	6.3	5.7	1.0	3.9
My Fair Lady	3.7	6.0	6.0	2.0	2.6
Who Gets Kissed	3.3	6.3	6.1	1.0	2.3
<i>Grand Mean</i>	4.6	5.3	5.6	1.7	3.2
<i>LSD .05</i> ³	1.6	2.0	0.4	–	1.1
<i>R</i> ² vs <i>DAP</i> ⁴	0.99	0.94	0.73	–	–

¹Vigor: 9=excellent; 5=average; 1=poor. Tillers: 5=most plants with tall tillers; 3=most plants have tillers, but not tall; 1=no or few tillers.

²Flavor: 5=excellent; 4=very good; 3=good; 2=medium; 1=poor.

³Means differing by more than this amount are significantly different at $P \leq .05$ based on Fisher's Protected LSD. Means in bold do not differ significantly from the highest in that column. – AOV not performed.

⁴R-squared value for linear regression of response vs. mean of actual days to harvest, if regression significant at $P < .05$. – Regression not performed.

Table 2. Yield, ear size, and quality of sugar-enhanced and synergistic sweet corn varieties in northern Indiana, 2017.

Cultivar	Seed Source ¹	Days to Harvest ²		Yield of Marketable Ears		Ave Ear Weight lb.	Ear Length in.	Ear Diameter in.	Shank Length in.	Ear Height in.	Husk Cover ³	Husk Tightness ³	Tip Fill ³	Overall ³
		Pred.	Actual	doz/A	ton/A									
Sweetness	CR	68	66-69	1,323	5.0	0.63	7.3	1.76	3.4	12.1	2.8	1.3	3.8	4.3
CSQBF 13-631	CR	72	69-71	1,186	6.3	0.89	7.5	1.88	5.9	18.3	4.1	2.1	3.6	7.0
CSQBF 14-773	CR	78	78	1,210	6.2	0.86	7.7	<i>1.83</i>	4.8	22.8	4.0	2.0	4.0	6.7
CSQBF 14-774	CR	78	78-80	992	5.6	0.95	7.2	1.83	7.0	24.3	<i>5.0</i>	2.7	4.3	7.3
My Fair Lady	HMS	75-78	76-78	1,339	6.7	0.83	7.7	1.97	3.8	22.3	3.4	<i>1.0</i>	2.6	3.7
Who Gets Kissed	HMS	78-84	78-80	1,081	5.5	0.84	8.0	1.93	4.7	25.0	4.2	2.3	3.3	4.7
<i>Grand Mean</i>			75	<i>1,188</i>	<i>5.9</i>	<i>0.83</i>	<i>7.6</i>	<i>1.87</i>	<i>4.9</i>	<i>20.8</i>	<i>3.9</i>	<i>1.9</i>	<i>3.6</i>	<i>5.6</i>
<i>LSD .05⁴</i>			-	<i>NS</i>	<i>NS</i>	<i>0.07</i>	<i>NS</i>	<i>0.12</i>	<i>1.1</i>	<i>1.8</i>	<i>NS</i>	<i>NS</i>	<i>0.76</i>	<i>1.9</i>

¹Seed Source: CR=Crookham; HMS=High Mowing Seeds.

²Days from planting to harvest. Predicted number is from seed supplier. Actual values are range for 3 replications.

³Husk cover: 5=more than 2 inches cover; 4=1.25-2 inches; 3=0.75-1.25 inches; 2=less than 0.75 inch; 1=ear exposed. Husk tightness: 1=loose; 3=very tight.

Tip fill: 5=kernels filled to tip of cob; 4=less than 0.5 inch unfilled; 3=0.5-1 inch unfilled; 2=more than 1 inch unfilled; 1=more than 2 inches unfilled.

Overall: 1=worst. 9 =best.

⁴Means differing by more than this amount are significantly different at $P \leq .05$ based on Fisher's Protected LSD. NS=not significant. Means in bold do not differ significantly from the highest in that column. Cultivars with means in italics were not included in AOV for that response due to 0 variance. – AOV not performed.