and 'Snowden' selections. Although 'Snowden' had good yields and chip ratings, it is not widely accepted by processors because of its potential for high glycoalkaloid levels which can negatively affect chip quality. Total yield of B0564-8 was statistically equivalent to an 'Atlantic' standard at all four locations and similar to 'Snowden' at three of four locations. Marketable yield of both numbered entries was about 92% of 'Atlantic'. B0564-8 had the most consistent conformation and highest overall appearance ratings of all varieties. Both numbered entries had significantly lower levels of hollow heart and IHN than 'Atlantic'. This translated into better chip ratings for the numbered entries compared to 'Atlantic'. A potential role for the new selections, especially B0564-8, may be as a late season chipper. B0564-8 could be recommended for late season plantings in the TCAA with the intent of filling June contracts when IHN becomes a potential problem with 'Atlantic'. Planting the numbered entries may improve the consistency of tuber quality and, in turn, production efficiency.

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Sweet Corn Variety Trials in Ohio: Recent Top Performers and Suggestions for Future Evaluations

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ADDITIONAL INDEX WORDS. crop quality, °Brix, plant height, ear height, ear length, ear diameter, shank length, row number, yield, *Zea mays*

SUMMARY. A total of 21 and 28 standard and experimental varieties of yellow and white *se*- and *sh2*-type sweet corn (*Zea mays*) were planted in 1999 and 2000 in Fremont and Wooster, Ohio, which are separated by 193.1 km (120 miles) and contain different soil types. Data are reported here for a subset of these varieties (eight yellow, two white) showing a consistently high level of use in Ohio and planted in both years. Endosperm types were planted in distinct, parallel experiments separated by a minimum of 79.9 m (262 ft) at each site. A randomized complete block design with four replications per variety (V) per location (L) was used, with measures of 13 production- and market-based variables taken from emergence to 48 hours after harvest. Soluble solids 48 hours after harvest were greater at Wooster than Fremont in the *sh2* study. Variety had a significant, independent effect on mean plant and ear height in the *se* and *sh2* study, respectively, although further analysis of year × variety (Y × V) and location × variety (L × V) interactions suggested that V affected additional traits. On average, 'Tuxedo' (*se*) and 'HMX6383S' (*sh2*) had superior com-

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binations of grower- and consumer-oriented traits. However, varieties with the highest levels of percent emergence and marketable yield tended to have lower levels of soluble solids, regardless of endosperm type. Y × V interactions were primarily due to changes in the magnitude of values for individual varieties in each year, not from changes in their relative ranking. The Y × L × V interaction was significant ($P \leq 0.05$) for marketable yield, plant and ear height, and the ratio of ear length to diameter in the *se* study, but zero variables in the *sh2* study. Coefficients of determination (R^2) for selected plant and ear traits were unaffected by location. Overall, R^2 values ranged from 0.04 (number of rows of kernels × ear diameter, *sh2* study) to 0.83 (shank length × total ear length, *sh2* study). These data reinforce that genetics strongly affect key traits in sweet corn and identify two potential top performers. The data also suggest that independent L or L × V effects may be minor relative to V effects, even when locations are separated by moderate distances and contain different soil types. Therefore, including more varieties but fewer sites may be warranted in future variety trials. The data also suggest that 1) ratings of variety performance should be based on objective measures of grower- and market-oriented traits and 2) shank length × total ear length and ear height × plant height relationships may be used to improve the efficiency of future evaluations.

Sweet corn crops must meet strict market requirements for quality and appearance (Rangarajan et al., 2002; Revilla and Tracy, 1997; Tracy, 2001). While marketable yield, plant and ear height, and other characteristics are important to growers, the appearance and dimensions of ears and the sensory properties of kernels are important to consumers of fresh market sweet corn (Tracy, 2001; Wolfe et al., 1997). Among other traits, consumers of fresh market sweet corn generally prefer 8 to 9-inch (20.3 to 22.9-cm) ears filled with 16 straight rows of small, deep, sweet, creamy, and aromatic kernels extending to the tip of the ear (Boyer and Shannon, 1983; Flora and Wiley, 1974a; Simonne et al., 1999; Tracy, 2001; Wong et al., 1994). These traits may be influenced by genotype and genotype × environment (e.g., location) interactions, especially on regional scales, and in-field management (Govindasamy et al., 1996; Rangarajan et al., 2002; Simonne et al., 1999; Tracy, 2001; Wolfe et al., 1997; Wong et al., 1994; Zhu et al., 1992). Also, many sweet corn varieties are developed under environments which differ from those in target production areas. Therefore, assessing the consistency of variety performance across locations and/or time is important to breeders and farmers (Busey, 1983).

Bachireddy et al. (1992) documented significant genotype × environment (G × E) effects in Louisiana, although using only one location. They also outlined the use of a variety selection method based on a single variable, yield stability, with little relevance to consumers. Simonne et al. (1999) described the use of an overall rank-sum index (based on several variables) to identify potentially superior varieties or groups of varieties. To be effective, both approaches require reliable information for a number of traits from local, systematic G × E studies. Growers, in particular, are inclined to rely most heavily on results from local evaluations, believing that distance alone is likely to create differences in performance between their farm and a remote test site. Still, multilocation, multiyear studies of many traits on numerous sweet corn varieties are resource-demanding and rare, including in Ohio. Yet, such studies are needed to assist in variety selection, maintain consumer satisfaction, and improve our understanding of the relative contributions of variety and environment to variability in major traits. They may also help make variety evaluations more efficient by focusing efforts on the leading determinants of crop performance (i.e., variety or environment).

In Ohio, sweet corn often ranks first among fresh vegetable commodities in area planted and second in value of production (United States Department of Agriculture–National Agricultural Statistics Service, 2003). About 55% to 65% of the crop (acreage basis) is marketed wholesale, including shipment to distant markets, with the remainder marketed by family-owned and/or operated retail outlets. Diverse markets lead the Ohio industry to plant a wide assortment of varieties (which differ in endosperm type and color, sensory, and other characteristics) in many different production conditions. Therefore, location and variety effects on grower- and consumer-oriented traits of fresh market sweet corn were documented to assist in selecting varieties and increasing the efficiency of future evaluations. Relationships between important traits were also studied to assist in the second objective, since stable relationships between selected traits may permit fewer direct measurements to be taken in evaluations.

Materials and methods

PLOT ESTABLISHMENT AND MAINTENANCE. A total of 21 and 28 standard and experimental varieties of yellow and white *se*- and *sh2*-type sweet corn were planted in early- to mid-May 1999 and 2000, respectively, in Fremont and Wooster, Ohio, per seed company and/or grower request. The annual performance of all 39 unique varieties and related selection recommendations have been discussed extensively in local, state, and regional extension publications (Kleinhenz and Schult, 1999, 2000). Data are reported here for a subset of these varieties (eight yellow, two white) planted in both years. The 10 varieties were chosen based on their consistently high level of use in Ohio, based on input from farmers and seed company representatives. White varieties were also included to estimate the rate of outcrossing within the studies. Yellow endosperm color is genetically dominant to white. Therefore, at harvest, calculating the percent of yellow kernels on a mainly white-kerneled ear provides an estimate of the rate of outcrossing among nearby plots and gives insight into potential xenia effects. Such estimates are typically unavailable in sweet corn variety trial reports, but relate to the potential trueness to type of samples from individual plots, particularly with respect to kernel-based traits affecting eating quality.

Endosperm types were planted in distinct, parallel studies separated by a minimum of 79.9 m (262 ft) at each location using a modified John Deere planter. A randomized complete block design with four replications per variety (V) per location (L) was used. Plots [four, 7.6-m (25-ft) rows on 76.2-cm (30-inch) centers] were established at the Vegetable Crops Research Branch in Fremont, Ohio [lat. 41° 21' N, long. 83° 07' W, elevation 193 m (633.2 ft)] on 8 May 1999 and 15 May 2000 and at the Ohio Agricultural Research and Development Center (OARDC) in

Wooster, Ohio [lat. 40° 47' N, long. 81° 55' W, elevation 310 m (1017.1 ft) on 7 May 1999 and 11 May 2000. Soil type at Fremont was a Kibbie Fine Sandy Loam (fine, Illitic, Mesic Mollic Ochraqualf) with 4.3% organic matter and pH = 6.6. Soil type at Wooster was a Wooster Silt Loam (fine-loamy, Mixed, Mesic, Typic Fragiudalf) with 3.0% organic matter and pH = 6.8. Fine sandy loam and silt loam soils cover about 126.8 thousand ha (313 thousand acres) and 7.21 million ha (17.8 million acres) of cropland, respectively, in Ohio (Beuerlein et al., 1996) and are often used in sweet corn production in the state. About 6.58 seed were delivered per meter of row (2.4 seed/ft) with ends of plots separated by 0.61 m (2 ft) at planting. Plots were shortened and thinned by hand after seedling establishment and measures of percent emergence to a length of 6.1 m (20 ft) and a population of 3.806 ± 0.558 plants per meter of row (1.16 ± 0.17 plants/ft) [49,943.2 plants/ha (20,212 plants/acre)]. Nutrient and pest management practices followed local recommendations and low soil moisture stress was minimized with overhead irrigation as described in Kleinhenz and Schult (1999, 2000). Daily and seasonal growing degree day (GDD) values were calculated according to the Barger equation [(daily minimum temperature + daily maximum temperature)/2]–9.4 °C (49 °F) as in Lass et al.(1993). Maxima >30.0 °C (86 °F) were set equal to 30.0 °C and minima <9.4 °C were set equal to 9.4 °C as in Arnold (1974). Temperature data were collected hourly at each site by the OARDC Weather System (Computing and Statistical Services and Communications and Technology, The Ohio Agricultural Research and Development Center, 2003), with seasonal values a sum of daily values.

Harvest and data collection. Plant and crop development were assessed regularly beginning at emergence. Readiness for harvest was assessed by counting days from 50% anthesis and visual examination of ears in each plot. Target harvest dates were 18 d after 50% anthesis for *se*-type varieties and 20 d for *sh2*-type varieties, with all plots of a given V at the same location harvested on the same day. Immediately before harvest, height to the top of the tassel and collar of the primary ear were measured on three plants in the center two rows of each plot. All ears were then removed by hand from the 10 center plants in the middle two rows of each plot (20 plants total per plot). The total weight of all ears from 20 plants and the number and weight of marketable ears were recorded. The following were recorded on five individual marketable ears per plot: ear length, ear diameter, number of rows of kernels, and shank length. Ears were considered nonmarketable if they were <17.8 cm (7 inches) long (excluding shank), not filled to the tip, or displayed evidence of incomplete pollination, disease, or insect damage. Randle et al. (1984) suggested that soluble solids measurements could be used as simple, rapid estimates of sweet corn kernel sucrose level. Zhu et al. (1992) also reported an overall R^2 of 0.99 between soluble solids and total sugar levels taken over a 5-d period in a total of three varieties of *su*-, *se*- and *sh2*-type sweet corn. In this study, soluble solids readings were taken on four mature marketable ears collected at harvest from each plot (16 ears/variety per location). Within 1 h after harvest, a 5.1-cm (2-inch) cross section from the middle of two ears per plot was frozen in liquid nitrogen, placed in sealed plastic containers and stored at –20.0 °C (–4 °F). The two remaining ears per plot remained in nylon mesh bags held at 22.2 °C (72 °F) for 48 h until similar cross-sections were removed, frozen in liquid nitrogen, and stored at –20.0 °C. Individual ear cross-sections were later removed from storage, immersed for 30 s in liquid nitrogen, turned cut surface down on a bench-top, covered with a clean cotton cloth and struck twice in the center with a hammer, dislodging all kernels intact. About 15 whole kernels were then placed in closed 20-mL polystyrene sample vials (Dilu Vials; Fisher Scientific, Pittsburgh, Pa.) and thawed over a period of 10 min in a recirculating temperature-controlled water bath maintained at 30 °C. Kernels were then crushed using a hand-held garlic press (Ekco Housewares, Inc., Franklin Park, Ill.) containing a 2 × 2 × 3 mm (0.8 × 0.8 × 0.12 inch) layer of cotton gauze, exchanged with each sample, beneath the kernels. About 1.5-mL aliquots of filtered kernel sap were dispensed directly to 1.7-mL polypropylene microcentrifuge tubes (Fisher Scientific) and spun at 2000 g_n for 8 min in a Labnet Mini centrifuge. Soluble solids readings were taken by placing 250 µL of the supernatant on an Abbe Mark II digital bench-top refractometer (Leica Microsystems, Inc., Buffalo, N.Y.) with readings adjusted to 20 °C (68.0 °F). Using this method, the interval between thawing and soluble solids measurement was 10 min.

A sum-based rank of the 10 varieties across all locations was determined using methods outlined in Kleinhenz and Schult (2000) and Simonne et al. (1999). Site-specific rankings of each variety were determined for percent emergence, marketable yield, and soluble solids in 1999 and 2000, with ties permitted. Annual rankings for individual traits were added to develop site-specific, study-wide rankings, which were then summed to create an overall V rank. The minimum and maximum possible site sum score equaled 10 and 50, respectively, and the minimum and maximum potential study sum rank index value equaled 20 and 100, respectively.

Statistical analysis. Data from *se* and *sh2* experiments were analyzed separately using Statistical Analysis System (SAS v. 8 for Windows; Statistical Analysis System, Cary, N.C.). Analysis of variance (ANOVA) was completed on main effects and interactions; effects were considered significant if $P \leq 0.05$. Means were separated using Fisher's protected least significant difference test (α = 0.05). Pearson correlation coefficients and their associated R^2 values were calculated to describe the extent of association among selected plant and ear traits.

Results

Thirteen variables were measured in 10 varieties over 4 site–year combinations, with data and selection recommendations for these and other varieties reported elsewhere (Kleinhenz and Schult, 1999, 2000). Therefore, major outcomes will be emphasized here. Values for most crop, plant and ear traits were greater ($\alpha \leq 0.05$) in 2000 than 1999, regardless of endosperm type (Table 1). Growing location (L) had a significant (α = 0.05), independent effect on only one variable as the mean soluble solids value recorded 48 h after harvest was greater at Wooster than Fremont in the *sh2* study (Table 2). Variety had a significant, independent effect (without an interaction with year and/or site) on only mean plant and ear height in the *se* and *sh2* study, respectively (Table 1). Significant year

× variety (Y × V) and year × location (Y × L) effects were recorded in both studies (Table 1). However, Y × V interactions were primarily due to changes in the magnitude of values for individual varieties in 1999 and 2000 and less from changes in their relative ranking (data not shown). The same was not true for Y × L interactions as the relative effect of planting at Fremont and Wooster on mean plant and ear height in the *se* study and shank and total ear length and number of rows of kernels per ear in the *sh2* study differed between years, although not significantly (data not shown). The Y × L × V interaction was significant ($P \leq 0.05$) for four variables (marketable yield, plant and ear height, and ear length to diameter) in the *se* study but zero variables in the *sh2* study (Table 1).

Of the 13 variables measured, only shank length in the *se* study and marketable yield and plant height in the *sh2* study were not affected by V (Table 1). Marketable yield ranged from 8.6 $t \cdot ha^{-1}$ (3.84 tons/acre) ('Spring Treat') to 12.4 $t \cdot ha^{-1}$ (5.53 tons/acre) ('HMX5349WE') in the *se* study and as a percent by weight of all ears collected from each plot ranged from 75% ('Incredible') to 90% ('Tuxedo'). Mean soluble solids values in the *se* study ranged from 19.1% (°Brix) ('HMX5349WE') to 22.0% ('Incredible') at harvest and 17.2% ('HMX5349WE') to 21.5% ('Spring Treat') 48 h after harvest (Table 2). In the *sh2* study, marketable yield ranged from 9.5 $t \cdot ha^{-1}$ (4.24 tons/acre) ('GSS0966 Attribute') to 12.3 $t \cdot ha^{-1}$ (5.49 tons/acre) ('HMX6383S'). Mean soluble solids values ranged from 15.9% ('Morning Star') to 17.6% ('GSS0966, Attribute') at harvest and 13.0% ('Morning Star') to 15.1% ('GSS0966, Attribute') 48 h after harvest (Table 2). Soluble solids data reported here are similar to those found by Zhu et al. (1992) for single *se*- and *sh2*-type varieties.

The minimum and maximum potential study sum rank index values equaled 20 and 100, respectively. Overall, the minimum and maximum observed values equaled 51 and 65, respectively (Table 3). In the *se* study, 'Tuxedo' and 'Tablemaster' had the lowest (most desirable) and highest study sum index values, respectively, while 'HMX6383S' and 'Morning Star' had the lowest and highest index values in the *sh2* study, respectively (Table 3). The difference between site sum scores for the *sh2* varieties 'HMS6383S' and 'Morning Star' were greater than the project average (4.7), with 'HMS6383S' having a lower score at Wooster than Fremont and 'Morning Star' having a lower score at Fremont than Wooster.

Overall R^2 values describing the extent of association between individual traits ranged from 0.15 (ear length to total ear length) to 0.79 (shank length to total ear length) in the *se* study and 0.09 (ear length to total ear length) to 0.83 (shank length to total ear length) in the *sh2* study (Table 4). Overall R^2 values for the association between soluble solids values at harvest and after storage were 0.22 (*se*) and 0.38 (*sh2*). The probability that random sampling would result in an R^2 value as far from or further from 0 than the overall R^2 value found here was less than 0.0001 for each relationship (Table 4). Differences between site-specific R^2 values for the same relationships in both studies were subjected to ANOVA and a *t* test ($\alpha = 0.05$) and found to be similar (data not shown). Overall and site-specific R^2 values for ear diameter to ear length and number of rows of kernels to ear length were ≤0.10 for both endosperm types (data not shown).

Discussion

A goal of this study was to examine key traits in a range of sweet corn varieties grown at two locations in Ohio (Fremont, Wooster) long thought to require local variety testing due to potential differences in climatic, soil and other conditions (personal communication). Fremont

Table 1. Results from analysis of variance regarding the influence of year, growing location and variety on crop, plant, ear and kernel traits in a total of 10 varieties of *se*- and *sh2*-type yellow and white sweet corn grown at Fremont and Wooster, Ohio in 1999 and 2000.

	Marketable yield		Ht			No.	Length				Soluble solids (%)	
	% by wt	$t \cdot ha^{-1}$	Plant	Ear[z]	Ear diam	of rows	Ear	Shank	Total	Ear l:d[y]	0 h	48 h
***se* endosperm**												
CV[x]	12.3	19.7	5.2	6.7	3.9	4.3	4.0	17.3	7.0	4.0	8.6	8.6
Year (Y)	NS	NS	***	***	**	***	***	***	***	***	NS	**
Location (L)	NS	*	NS	***	NS	***	NS	NS	*	NS	NS	NS
Variety (V)	***	***	***	***	***	***	***	NS	*	***	***	***
Y × L	*	**	***	***	NS	NS	**	NS	*	**	NS	**
Y × V	*	*	NS	***	***	***	**	*	*	***	**	*
L × V	NS	NS	NS	***	NS	*	*	NS	NS	**	NS	NS
Y × L × V	NS	*	NS	**	*	NS	NS	NS	NS	***	NS	NS
***sh2* endosperm**												
CV	8.6	14.4	19.1	10.6	4.1	4.3	3.4	14.1	5.3	3.9	7.3	9.5
Y	NS	***	**	***	***	***	***	***	*	***	***	***
L	NS	NS	NS	NS	NS	***	NS	***	***	*	NS	*
V	NS	***	NS	***	***	***	***	***	***	***	***	***
Y × L	**	***	NS	NS	NS	***	NS	***	***	NS	NS	NS
Y × V	*	**	NS	NS	**	NS	***	*	*	**	**	*
L × V	NS	NS	NS	NS	**	NS	NS	NS	NS	**	**	NS
Y × L × V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]Height from soil surface to collar of primary ear.
[y]Ear length to diameter ratio.
[x]Coefficient of variation.
NS,*,**,***Nonsignificant or significant main effects and interactions within each endosperm type at $P = 0.05$, 0.01, or 0.001, respectively.

and Wooster are separated by about 193.1 km (120 miles) and contain different soil types with contrasting particle sizes, organic matter content and other characteristics. Despite these differences, growing location alone had few major effects on key grower- and consumer-oriented traits in this study (Table 1). Climatic conditions during the study may help explain the relative lack of independent L effects observed here. Except for unusually high rainfall in Fremont in 2000, the rates and total accumulation of rainfall and irrigation were similar between locations and years and consistent with historical averages for each site (data not shown). On average, Wooster accumulated 58 more GDD than Fremont each year, although annual seasonal project-wide averages (1011 in 1999, 994 in 2000) were similar.

Variety affected many traits in both studies, although to degrees partly dependent on year or site. Similar numbers of significant ($\alpha = 0.05$) Y × V and L × V interactions were found in both studies, although Y × V interactions outnumbered L × V interactions in both studies (Table 1). Values for marketable yield ($t \cdot ha^{-1}$), ear and plant height, total ear length, soluble solids, and other variables tended to be lower in 1999 than 2000, regardless of endosperm type (Table 2). This was unexpected given the prevailing climatic conditions; however, unusually high rainfall in Fremont in 2000 or an unmeasured soil or other property may have contributed to seasonal effects.

Rank-sum indices have been proposed to assist in variety selection (Kleinhenz and Schult, 2000; Simonne et al., 1999), partly because they can provide objective, easily understood assessments of overall variety performance based on grower- and consumer-oriented traits. In this study, the minimum and maximum potential study sum rank index values equaled 20 and 100, respectively, while the minimum and maximum observed values equaled 51 and 65, respectively (Table 3). Site-specific rank index values deviated marginally in most varieties, with scores for only two *sh2* varieties ('HMS6383S', 'Morning Star') having a greater than average difference between locations. 'Tuxedo' (*se*) and 'HMX6383S' (*sh2*) had the lowest study sum index values, suggesting that they had a superior combination of grower- and consumer-oriented traits under these experimental conditions. Yet, in summing scores for soluble solids values and plotting them against

Table 2. Year, growing location and variety effects on crop, plant, ear and kernel traits of a total of 10 varieties of *se*- and *sh2*-type yellow and white sweet corn planted at Fremont and Wooster, Ohio in 1999 and 2000; 1.0 $t \cdot ha^{-1}$ = 0.45 ton/acre, 1.0 cm = 0.39 inch.

	Marketable yield					No.					Soluble	
	%		Ht		Ear	of		Length		Ear	solids (%)	
	by wt	$t \cdot ha^{-1}$	Plant	Ear[z]	diam	rows	Ear	Shank	Total	l:d[y]	0 h	48 h
***se* endosperm**												
Year												
1999	83	10.6	172	54	4.3	14.3	21.4	8.1	29.4	5.0	20.7	18.9
2000	80	11.5	202	69	4.2	15.7	20.1	11.6	31.8	4.8	21.3	20.0
$LSD_{0.05}$	4.5	1.0	4.4	2.0	0.1	0.3	0.4	0.8	1.0	0.1	0.8	0.8
Location												
Fremont	83	11.5	189	64	4.3	15.3	20.9	10.2	31.1	4.9	20.5	19.4
Wooster	81	10.5	185	60	4.3	14.8	20.6	9.6	30.1	4.9	21.6	19.7
$LSD_{0.05}$	4.5	1.0	4.4	2.0	0.1	0.3	0.4	0.8	1.0	0.1	0.8	0.8
Variety[x]												
HMX5349WE	88 a	12.4 a	200 a	74 a	4.2 b	14.0 b	20.6 bc	9.7 ab	30.3 ab	5.0 c	19.1 b	17.2 c
Incredible	75 b	10.7 b	192 b	70 b	4.6 a	17.1 a	20.1 c	9.2 b	29.3 b	4.4 e	22.0 a	20.7 a
Spring Treat[w]	78 b	8.6 c	150 c	39 d	4.0 c	12.7 c	20.2 c	10.7 a	30.9 a	5.1 b	21.5 a	21.5 a
Tablemaster	79 b	11.3 ab	204 a	72 ab	4.5 a	17.1 a	21.0 b	10.0 ab	31.0 a	4.7 d	21.4 a	19.5 b
Tuxedo	90 a	12.2 ab	191 b	55 c	4.1 bc	14.1 b	21.7 a	9.8 ab	31.5 a	5.4 a	21.0 a	19.2 b
$LSD_{0.05}$	7.2	1.5	7.0	3.0	0.1	0.5	0.6	1.2	1.5	0.1	1.3	1.2
***sh2* endosperm**												
Year												
1999	88	10.6	175	60	4.3	15.1	20.4	9.0	29.4	4.8	15.7	12.8
2000	88	12.0	199	72	4.2	16.0	18.9	11.4	30.3	4.6	17.7	15.3
$LSD_{0.05}$	3.4	0.7	15.9	3.1	0.1	0.3	0.3	0.7	0.7	0.1	0.5	0.6
Location												
Fremont	88	11.2	185	67	4.2	16.0	19.7	11.0	30.7	4.7	16.6	13.8
Wooster	88	11.4	188	66	4.3	15.1	19.6	9.4	28.9	4.6	16.7	14.3
$LSD_{0.05}$	3.4	0.7	15.9	3.1	0.1	0.3	0.3	0.7	0.7	0.1	0.5	0.6
Variety												
GSS0966 Attribute	86 b	9.5 c	193 a	74 a	4.1 c	15.6 bc	18.8 d	11.9 a	30.7 a	4.6 b	17.6 a	15.1 a
GSS3587	91 a	11.0 b	181 a	58 c	4.2 b	15.1 d	18.8 d	8.5 c	27.3 c	4.4 c	16.6 bc	14.5 a
HMS6383S	86 ab	12.3 a	189 a	69 b	4.5 a	15.7 b	20.3 b	10.3 b	30.6 a	4.5 bc	17.1 ab	14.5 a
Ice Queen	88 ab	11.9 ab	195 a	61 c	4.1 c	15.2 cd	20.9 a	10.6 b	31.5 a	5.1 a	16.0 c	13.1 b
Morning Star	88 ab	11.8 ab	175 a	69 ab	4.2 bc	16.2 a	19.4 c	9.7 b	29.1 b	4.6 b	15.9 c	13.0 b
$LSD_{0.05}$	5.3	1.2	25.1	4.9	0.1	0.5	0.5	1.0	1.2	0.1	0.9	0.9

[z]Height from soil surface to collar of primary ear.
[y]Ear length to diameter ratio.
[x]For variety, means within the same column followed by the same letter are not significantly different according to Fisher's protected least significant difference test at α = 0.05 ($LSD_{0.05}$).
[w]Soluble solids not measured in 'Spring Treat' in 1999 at Wooster, Ohio.

sums for grower-friendly traits (percent emergence, marketable yield), it is interesting to note that varieties with the lowest sums (i.e., potentially most desirable performance) for grower-friendly traits had the highest sums for soluble solids, regardless of endosperm type (data not shown). Nevertheless, these data illustrate the potential value of rank-sum indices based on a number of traits in identifying varieties with an optimal combination of grower- and consumer-oriented traits.

Isolation of varieties differing in endosperm type and/or color in time and/or space is common in variety trials. However, due to resource limitations, the same studies rarely include specific tactics to ensure self-pollination within individual plots. More commonly, border rows are assumed to be sufficient to minimize cross-pollination and xenia effects (the direct effects of pollen on kernel phenotype). Xenia may influence eating quality but its effects are usually small and often ignored (Andrews, 1963; Tracy, 2001). In the current study, overall outcrossing rates were estimated to be 46% in 'HMX5349WE' (*se*) and 19% in 'Ice Queen' (*sh2*) in 1999. Thresholds of acceptability in outcrossing rates in variety trials are not well known; however, given the potential influence of outcrossing on indicators of kernel eating quality, low rates are preferred. Andrews (1963) reported xenia effects on various kernel traits (e.g., kernel weight, embryo weight, pericarp content) but, interestingly, not soluble solids. Ongoing changes in sweet corn genetics increase the complexity of isolation requirements. To achieve target levels of crop quality and trueness to type in experimental samples, growers and study managers are encouraged to minimize cross-pollination.

A number of R^2 values describing relationships between selected traits were large enough to suggest that useful correlations may exist in important, commonly measured traits (Table 4). For example, measures of soluble solids have been proposed for simple, reliable estimation of kernel sucrose (Randle et al., 1984) and moisture (Drake and Nelson, 1979) content and crop maturity (Becwar et al., 1977; Drake and Nelson, 1979; Ruan et al., 1999). Also, Zhu et al. (1992) reported a negative relationship between soluble solids and total sugars with an overall R^2 of 0.99.

Table 3. Rank-sum index values (cumulative for 1999, 2000), after Simonne et al. (1999) and Kleinhenz and Schult (2000), of 10 varieties of *se*- and *sh2*-type yellow and white sweet corn grown at Fremont and Wooster, Ohio in 1999 and 2000; E = emergence, SS = soluble solids; 1.0 t·ha^{-1} = 0.45 ton/acre.

	Fremont						Wooster						
		Marketable yield						Marketable yield					
	%	%		SS		Site	%	%		SS[z]		Site	Study
	E	by wt	t·ha^{-1}	0 h	48 h	sum	E	by wt	t·ha^{-1}	0 h	48 h	sum	sum
***se* endosperm**													
Variety[y]													
HMX5349WE	5[y]	4	2	9	10	30	3	2	3	9	9	26	56
Incredible	7	6	7	5	4	29	9	8	4	3	3	27	56
Spring Treat[z]	7	10	5	6	4	32	8	8	4	---	---	---	---
Tablemaster	5	5	8	5	6	29	7	7	5	6	6	31	60
Tuxedo	2	5	6	5	6	24	3	6	7	6	6	27	51
***sh2* endosperm**													
Variety													
GSS0966 Attribute	8	10	6	3	6	33	5	8	9	4	2	28	61
GSS3587	3	6	7	5	6	27	3	8	7	7	4	29	56
HMS6383S	7	6	5	7	4	29	7	2	4	3	6	22	51
Ice Queen	5	4	2	8	9	28	5	5	2	8	8	28	56
Morning Star	3	4	7	5	5	24	8	7	8	8	10	41	65

[z]Soluble solids not measured in 'Spring Treat' in 1999 at Wooster, Ohio.

[y]The relative ranking of each variety was determined for each trait in 1999 and 2000, with ties permitted. Values for individual traits above are the sum of values for the variety's rank for that trait in 1999 and 2000. Therefore, the minimum and maximum possible site sum score equals 10 and 50, respectively.

Table 4. Coefficients of determination (R^2) calculated from Pearson correlation coefficients describing relationships between individual plant and ear traits for a total of 10 varieties of *se*- and *sh2*-type yellow and white sweet corn grown at Fremont and Wooster, Ohio in 1999 and 2000. All relationships were positive.

		Location					
		Fremont		Wooster		Overall	
Relationship	Type	N[z]	R^2	N	R^2	N	R^2
Ear height to plant height	*se*	155	0.66****	155	0.64****	310	0.65****
	sh2	155	0.59****	157	0.41****	312	0.50****
Ear length to total ear length	*se*	200	0.12****	213	0.17****	413	0.15****
	sh2	200	0.16***	195	0.03*	395	0.09****
Shank length to total ear length	*se*	200	0.83****	213	0.76****	413	0.79****
	sh2	200	0.82****	194	0.82****	395	0.83****
Number rows to ear diameter	*se*	200	0.26****	213	0.22****	413	0.23****
	sh2	199	0.08****	194	0.05**	394	0.04****
Soluble solids 48 h after harvest	*se*	40	0.28***	35	0.17*	75	0.22****
to soluble solids at harvest	*sh2*	39	0.31***	40	0.43****	79	0.38****

[z]N = number of observations used to calculate correlation coefficient.

*,**,***,****Significant for associated R^2 value at $P < 0.05$, <0.01, <0.001, or <0.0001, respectively.

However, they cautioned against the use of soluble solids readings in the field as estimates of sugar content without additional information as correlations were impacted by G × E interactions, although in a small number of varieties. Nevertheless, exploring potentially consistent relationships between selected traits, including soluble solids and the components of sensory quality, may benefit large-scale variety evaluations. Likewise, the shank length to total ear length relationship may also be useful because measurements of one could be used to estimate the other, with the same process used for ear height to plant height. Though validation of these relationships in other studies may be warranted, it is important to note that location had little effect on R^2 values for relationships between selected traits in this study. Although several differences between R^2 values for each site appeared to be large (Table 4), especially in the *sh2* study, results from ANOVA and *t* tests ($\alpha = 0.05$) suggest that site did not significantly impact R^2 values in either endosperm type (data not shown).

In this study, V and L × V effects on key sweet corn traits appeared to be more pronounced than independent L effects. 'Tuxedo' (*se*) and 'HMX6383S' (*sh2*) had the lowest study sum rank index values, suggesting that they had a superior combination of grower- and consumer-oriented traits under these experimental conditions. Relatively minor independent L effects suggest that routine testing at both Fremont and Wooster in the same year may not be required. The same may be true of various sites within neighboring states (e.g., Indiana, Kentucky, Michigan, Pennsylvania) more separated by distance than historical weather patterns or major soil classification. White and Brecht (1998) reported similar reducing sugar content in commercial varieties grown on Histosols and Entisols in Florida, also suggesting that soil type alone may have minor effects on some key traits. Bachireddy et al. (1992) found significant year × genotype effects on yield in thirty hybrids planted over five years, but at the same location, in Louisiana. Based on information contained in this and previous reports, it is reasonable to conclude that, at state or multicounty scales, maximizing the number of genotypes under evaluation, perhaps at the expense of increasing the number of sites used, may benefit fresh market sweet corn variety evaluation and selection projects, especially when resources are limited. At minimum, the data call for having persuasive evidence that location effects are probable when planning variety evaluations. Limiting the number of study sites may provide opportunities to examine management (e.g., planting date, spacing, irrigation, harvest date) effects on key traits, a number of which appear to depend on variety (Flora and Wiley, 1974b; Michaels and Andrew, 1986; Rangarajan et al., 2002; Revilla and Tracy, 1995; White, 1984). For example, Revilla and Tracy (1995) reported significant planting date × cultivar interaction effects on 20 of 34 morphological traits studied in 58 open-pollinated cultivars. Finally, the data also indicate that ratings of variety performance should be based on objective measures of grower- and market-oriented traits, including those related to eating quality. Most hybrids tend to lack an important character, requiring that compromises be made in selection (Tracy, 2001). Ideally, these compromises are guided by the relative importance of various traits in given markets (Tracy, 2001). In Ohio, collectively, this would require the availability of adapted yellow, white and bicolor varieties of all major endosperm types. Therefore, our approach in variety evaluation has been to emphasize the inclusion of *se* and *sh2*-type varieties but, due to resource limitations, one endosperm color. Endosperm color is changed every 2 years.

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