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Common Smut Reduces Sweet Corn Yield and Ear Processing Quality

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***Abstract*. The impact of natural infection of *Ustilago maydis* (causal agent of common smut) on processing characteristics of three F_1 hybrid sweet corn (*Zea mays* L.) cultivars was evaluated in a 2-year study with early and late spring planting dates. At harvest maturity, size and location of galls were recorded and quality characteristics measured. Galls on the lower stalk, upper stalk, and tassel reduced fresh weight and diameter of husked ears, whereas galls on the base of the stalk reduced fresh weight only. Ear length was reduced by galls on the upper stalk. As gall size increased from 0 to greater than 10.2 cm in diameter, ear fresh weight and diameter decreased. The presence of galls greater than 10.2 cm in diameter reduced ear length. Kernel depth was unaffected by size or location of gall. Additional ears of the same three cultivars were sampled from commercial fields planted in midseason near Walla Walla and Patterson, WA. Galls located on the upper and lower stalk reduced fresh weight, length, and diameter, whereas galls on the base of the stalk reduced fresh weight only. As gall size increased, fresh weight, length, diameter, and kernel depth decreased.**

Oregon and Washington produce 30% of the U.S. processed sweet corn with a 2009 farm market value of $120,512,000 (U.S. Department of Agriculture, 2009). The majority is produced in the Columbia Basin (central Washington and north–central Oregon) with yields averaging 23.5 $t \cdot ha^{-1}$. The area under production of processing sweet corn increased from ≈24,600 ha in 1987 to 56,000 ha in 2002.

Common smut, caused by the fungus *Ustilago maydis*, occurs worldwide and can cause yield losses in dent corn that range from a trace to 10% (White, 1999). Losses occur when galls replace the kernels of the ear or when a gall on the plant causes the quality of the ear to decrease. Losses resulting from common smut on sweet corn crops can be much greater as a result of the high susceptibility of flint corn, an ancestor of sweet corn (Bowjanowski, 1969). Fungicides are not effective in controlling this disease (Clough et al., 2001, 2003).

Since 1996, the incidence of common smut of sweet corn and field corn in the Columbia Basin of Oregon and Washington has increased from non-detectable levels to infection of most fields throughout the region (Clough et al., 2002). Increased area of production and dependence on smut-susceptible cultivars may have been responsible. The extent of losses resulting from common smut in sweet corn has not been determined, but major damage has been reported by the sweet corn processing industry since that time. Processing losses have been the result of increased labor costs for removing smutted ears, purchase of additional processing equipment to clean smutted corn, and end-product contamination by spores in the wash water resulting in unacceptable quality of ear cobbettes. Direct grower losses have occurred as a result of heavily smutted fields being "passed over" for harvest.

Yield losses resulting from common smut have in the past been attributed primarily to infection of the ear itself. The objective of the work reported here was to determine whether a relationship exists between ear quality and galls located elsewhere on the corn plant. Previous research from the early 1900s suggests that there is quality loss to the ear when the plant is infected with a smut gall (Immer and Christensen, 1928; Johnson and Christensen, 1935); however, an assessment of loss on infected modern sweet corn cultivars has not been explored.

Materials and Methods

Plots were seeded to 76,000 plants/ha on 4 May and 13 June in 2002 and on 2 May and 6 June in 2003 on the Hermiston Agricultural Research and Extension Center (HAREC) on Adkins fine sandy loam (coarse-loamy, mixed mesic Xerollic Camborthid, pH 6.7, 0.9% organic matter). The four 9.2-m rows/plot were spaced 0.76 m apart. The three hybrids evaluated, 'Sheba' (Seminis, Nampa, ID), 'Sockeye' (Harris Moran Seed Co., Modesto, CA), and 'Supersweet Jubilee' (Rogers, Boise, ID), represented early, mid, and late maturing varieties (1510, 1687, and 1750 heat units), respectively. Normal commercial production practices were followed (Oregon State University Cooperative Extension Service, 2004). The experimental design was a randomized complete block with four replications.

Ear maturity was determined using the microwave procedure developed by Becwar et al. (1977). Ears with the sugary (*su*) endosperm mutants ('Sockeye') were harvested when kernel moisture ranged from 71% to 74% and ears of the shrunken 2 (sh_2) endosperm mutants ('Sheba', 'Supersweet Jubilee') were harvested in the 75% to 77% moisture range.

For each planting date, and at optimum moisture, ears were sampled from plants with either no gall or only a single gall. Gall location on the plant was recorded as on the base (between brace roots and soil), lower stalk (between base and ear), upper stalk (between ear and tassel), or tassel. Gall size (0, less than 5, 5.1 to 10.2, greater than 10.2 cm diameter) was measured and recorded, and fresh weight, length, diameter, and kernel depth of the husked ear were measured. Data were subjected to analysis of variance by SAS General Linear Model procedures with mean separation by Fisher's protected least significant difference (PROC GLM; SAS Institute Inc., 2004) to determine the impact of gall location and size on these important processing characteristics (Stall et al., 1989).

In 2003, additional ears of the same cultivars were sampled from four locations in three commercial fields, each planted to one cultivar, in late June near Walla Walla and Patterson, WA. Field sampling technique and quality evaluation were as previously described except 'Supersweet Jubilee' was detasseled before harvest, so effects associated with tassel location could not be evaluated.

Results

Experiment station trials. In the early planting in 2002, no galls were found on the base or upper stalk for 'Sockeye', and only small galls (less than 5.1 cm) were noted at the other locations. Galls did not occur on the lower or upper stalks for 'Sheba', and with the later planting, there were no galls on the upper stalk.

In the early planting in 2003, no galls were found on the base or lower or upper stalk for 'Sockeye', and none were observed at any location for 'Sheba'. Galls were not found on the lower stalk or tassels of 'Supersweet Jubilee' with the early planting or on the tassels with the later planting. This resulted in several minor interactions affecting fresh weight and diameter involving year, planting, cultivar, gall location, and gall size (Table 1).

Only 1.7% of the 1128 plants sampled had a gall on the tassel larger than 10.2 cm in

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Table 1. Sweet corn ear quality as affected by year, planting, cultivar, gall location, and gall size in *Ustilago maydis*-infected plants in 2002 and 2003 at Hermiston, OR.

	Fresh wt (g)	Diam (cm)	Length (cm)	Kernel depth (cm)
Year (Y)				
2002	274	4.67	21.0	0.84
2003	288	4.92	20.3	1.02
	***	****	NS	****
Planting (P)				
Early	284	4.84	20.5	0.97
Late	277	4.74	21.2	0.88
	NS	***	**	*
Cultivar[z] (C)				
Sheba	285 a	4.85 a	21.2 a	0.91 ab
Sockeye	262 b	4.67 b	20.6 b	0.86 b
Supersweet Jubilee	296 a	4.83 a	21.1 a	0.96 a
	****	****	****	*
Gall location (L)				
None	297 a	4.89 a	21.2 a	0.96
Base	282 b	4.81 ab	20.8 ab	0.91
Lower stalk	251 c	4.57 c	20.6 b	0.86
Upper stalk	242 c	4.45 d	19.9 c	0.84
Tassel	281 b	4.77 b	21.1 a	0.88
	****	****	**	NS
Gall size (cm) (S)				
0	297 a	4.89 a	21.2 a	0.96
Less than 5.1	277 b	4.75 b	20.9 ab	0.88
5.1–10.2	266 c	4.65 c	20.8 b	0.87
Greater than 10.2	239 d	4.51 d	20.3 c	0.84
	****	****	**	NS
Interactions				
Y × L	**	NS	NS	NS
P × L	*	NS	NS	NS
Y × P × L	*	****	NS	NS
C × L	*	NS	NS	NS
P × S	*	NS	NS	NS
P × C × S	*	NS	NS	NS
L × S	*	*	NS	NS

[z]Cultivar means of uninfected controls.
****, ***, **, *, NS Significant at $P \leq 0.0001$, $P \leq 0.001$, $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 2. Sweet corn ear fresh weight as affected by cultivar and gall location interaction in *Ustilago maydis*-infected plants in 2002 and 2003 at Hermiston, OR.

Gall location	Cultivar		
	Sockeye	Sheba	Supersweet Jubilee
	Wt (g)		
None	278 a	290 a	322 a
Base	241 c	273 ab	296 b
Lower	229 c	239 b	277 c
Upper	234 c	257 ab	242 d
Tassel	270 b	291 a	301 b
	****	*	****

****, *Significant at $P \leq 0.0001$ or $P \leq 0.05$, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

diameter, and 89% of tassels observed had no gall or a gall less than 5.1 cm in size, resulting in cultivar × gall location and gall location × size interactions.

Sweet corn ear fresh weight was greater in 2003 than in 2002 but was unaffected by time of planting (Table 1). Ear fresh weight was greater for 'Supersweet Jubilee' and 'Sheba' than for 'Sockeye'. A gall on the base or tassel of the plant reduced ear fresh weight, which was further reduced by a gall on the lower or upper stalk. Ear fresh weight decreased as gall size increased.

Ear fresh weight was influenced by interactions between year, planting and gall location, cultivar and gall location, planting, cultivar and gall size, and gall location and gall size. Fresh weight was reduced by a gall on the lower stalk and further reduced by a gall on the upper stalk for the 2002 early planting (data not shown). With the later planting, galls at both locations reduced ear fresh weight, but the decrease was not statistically significant for a gall on the upper stalk. In the 2003 early planting, no galls were found on the lower stalk and only a gall on the tassels reduced ear fresh weight. Galls at all locations reduced ear fresh weight for the 2003 late planting with the largest decrease from a gall on the upper stalk.

Ear fresh weight was reduced by galls at all locations with 'Sockeye' and 'Supersweet Jubilee' but was reduced only by a gall on the lower stalk with 'Sheba' (Table 2).

With the early planting date, gall size did not affect ear fresh weight for 'Sheba' but fresh weight decreased with a gall 5.1 to 10.2 cm in diameter for 'Sockeye' and decreased as gall size increased for 'Supersweet Jubilee' (Table 3). With the late planting, fresh weight decreased as gall size increased for both 'Sockeye' and 'Supersweet Jubilee' but only decreased with the largest sized gall (greater than 10.2 cm) for 'Sheba'.

On the base and tassels of the plant, only the largest gall reduced ear fresh weight (Table 4). A gall of any size decreased fresh weight if on the lower stalk with the largest reduction occurring with the largest gall. A gall of 5.1 to 10.2 cm on the upper stalk reduced ear fresh weight, whereas a gall greater than 10.2 cm in diameter further decreased ear weight.

Ear diameter was greater in 2003 than in 2002, decreased from the early to later planting, and decreased as gall size increased (Table 1). Diameter decreased with a gall on the tassel, decreased further with a gall on the lower stalk, but was reduced most when the gall was located on the upper stalk. However, ear diameter was affected by interactions between year, time of planting and gall location, and gall size and gall location.

In 2002 with the early planting date, ear diameter was reduced by a gall on the lower stalk and further decreased by a gall on the upper stalk (data not shown). With the later planting, a gall at either location reduced ear diameter similarly. Gall location did not affect ear diameter with the early planting in 2003. With the later planting, however, a gall on the tassels reduced ear diameter, a gall on the lower stalk further decreased the diameter, whereas an upper stalk gall produced the smallest diameter ear.

Ear diameter was unaffected by galls on the base of the plant but was reduced by the presence of galls on the lower stalk (Table 5). A gall less than 5.1 cm on the upper stalk did not impact ear diameter, but a gall from 5.1 to 10.2 cm decreased ear diameter, and a gall greater than 10.2 cm decreased ear diameter further. On the tassel, only a gall greater than 10.2 cm decreased ear diameter.

Ear length was similar in 2002 and 2003 and increased slightly from the early to the late planting (Table 1). Ears of 'Sheba' and 'Supersweet Jubilee' were similar in length and longer than those of 'Sockeye'. Ear length was reduced by a gall on the lower or upper stalk and by a gall of 5.1 cm or larger.

Kernel depth was greater in 2003 than 2002, decreased from the early to late planting, and differed between cultivars but was not influenced significantly by either gall location or gall size.

Commercial trials. Results similar to those of the experiment station plantings were obtained from the commercial production fields. 'Sockeye' ear fresh weight was reduced by a gall on the base and further decreased by a lower stalk gall; none were found on the upper stalk (Table 6). Ear diameter also decreased with a gall on either the base or lower stalk, whereas ear length and kernel depth were reduced only by a gall found on the lower stalk. Ear weight tended to decrease as gall size increased, but only a gall greater than 10.2 cm significantly reduced ear weight. Diameter, length, and kernel depth were unaffected by gall size.

Ear fresh weight of 'Sheba' was reduced by a gall on the base, decreased further by a lower stalk gall, but reduced the most by a gall on the upper stalk (Table 7). Both

Table 3. Sweet corn ear fresh weight as affected by cultivar, planting and gall size interaction in *Ustilago maydis*-infected plants in 2002 and 2003 at Hermiston, OR.

	Cultivar					
	Sockeye		Sheba		Supersweet Jubilee	
	Early	Late	Early	Late	Early	Late
Gall size (cm)	Wt (g)					
0	280 a	275 a	277	295 a	327 a	317 a
Less than 5.1	280 a	252 b	270	290 a	285 b	307 ab
5.1–10.2	202 b	230 c	305	285 a	265 b	295 b
Greater than 10.2	237 ab	210 d	—	237 b	207 c	262 c
	*	***	NS	***	****	****

****, ***, *, NS Significant at $P \leq 0.0001$, $P \leq 0.001$, $P \leq 0.05$, or non-significant, respectively. Means followed by different letters significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 4. Sweet corn ear fresh weight as affected by gall location and gall size interaction in *Ustilago maydis*-infected plants in 2002 and 2003 at Hermiston, OR.

	Gall location			
	Base	Lower stalk	Upper stalk	Tassel
Gall size (cm)	Wt (g)			
0	297 a	297 a	297 a	297 a
Less than 5.1	293 a	257 b	294 a	280 ab
5.1–10.2	282 ab	256 b	256 b	299 a
Greater than 10.2	271 b	238 c	153 c	263 b
	***	****	****	****

****, ***Significant at $P \leq 0.0001$ or $P \leq 0.001$, respectively. Means followed by different letters significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 5. Sweet corn ear diameter as affected by gall location and gall size interaction in *Ustilago maydis*-infected plants in 2002 and 2003 at Hermiston, OR.

	Gall location			
	Base	Lower stalk	Upper stalk	Tassel
Gall size (cm)	Diam (cm)			
0	4.89	4.89 a	4.89 a	4.89 a
Less than 5.1	4.83	4.58 b	4.91 a	4.78 a
5.1–10.2	4.88	4.59 b	4.52 b	4.74 a
Greater than 10.2	4.73	4.54 b	3.75 c	4.48 b
	NS	****	****	**

****, **, NS Significant at $P \leq 0.0001$, $P \leq 0.01$, or nonsignificant, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 6. 'Sockeye' sweet corn ear quality as affected by gall location and gall size in *Ustilago maydis*-infected plants, commercial fields in 2003.

	Fresh wt (g)	Diam (cm)	Length (cm)	Kernel depth (cm)
Gall location				
None	264 a	4.94 b	19.3 a	0.89 ab
Base	238 b	4.75 c	19.3 ab	0.87 bc
Lower stalk	232 c	4.64 c	18.4 b	0.82 c
Upper stalk	—	—	—	—
Tassel	282 a	5.11 a	20.1 a	0.93 a
	****	****	**	*
Gall size (cm)				
0	264 a	4.94	20.0	0.91
Less than 5.1	250 a	4.83	19.4	0.91
5.1–10.2	243 ab	4.90	19.2	0.89
Greater than 10.2	218 b	4.77	18.7	0.86
	**	NS	NS	NS

****, **, *, NS Significant at $P \leq 0.0001$, $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

diameter and length were reduced by a lower stalk gall and further reduced by a gall on the upper stalk. Kernel depth was unaffected by gall location. Fresh weight, diameter, and length were reduced by a gall 5.1 cm or greater, whereas kernel depth was reduced only by a 5.1- to 10.2-cm gall. Ear fresh weight, diameter, and kernel depth were influenced by interactions between gall location and gall size. Fresh weight was reduced by a gall of 5.1 cm or larger on the base or lower stalk and by a small- or medium-sized gall on the upper stalk. There were no galls greater than 10.2 cm at that location and no medium or large galls on the tassel (data not shown). Ear diameter was unaffected by a gall on the base or tassels but was reduced by a gall greater than 10.2 cm on the lower stalk or a gall of 5.1 to 10.2 cm on the upper stalk. Kernel depth decreased only with a gall of 5.1 to 10.2 cm on the upper stalk.

Fresh weight, diameter, length, and kernel depth of 'Supersweet Jubilee' ears were unaffected by gall location (Table 8). Although they tended to decrease as gall size increased, fresh weight, diameter, and length were significantly reduced only by a gall greater than 10.2 cm in diameter. Kernel depth was unaffected by gall size. All cultivars were impacted by interactions between gall location and gall size. Fresh weight, diameter, length, and kernel depth were reduced only by a gall greater than 10.2 cm located on the upper stalk (data not shown).

Discussion

The data presented here indicate a yield loss beyond the direct ear loss (average 7.3% for 6 cultivars evaluated over 12 years; Clough and Hamm, 2009) that occurs from an ear infection by common smut. In these trials, fresh weight loss of non-infected ears averaged 19.5%, 16%, and 6.8% as a result of a single gall on the upper stalk, lower stalk, or stalk base, respectively; this translates into a significant additional tonnage loss coming out of the field. Galls on the upper stalk have the greatest impact, significantly decreasing ear length, diameter, and kernel depth. A gall on the lower stalk or base reduces ear diameter and length but does not affect kernel depth. Ear fresh weight decreased 6.3%, 10.7%, and 19.7% with a single gall less than 5.1 cm, 5.1 to 10.2 cm, or greater than 10.2 cm, respectively. Ear diameter and length also decreased as gall size increased, whereas kernel depth was reduced only by a gall greater than 10.2 cm. These changes in ear quality reduce processing uses and limit product recovery.

Yield of field corn plants infected with a single gall was reduced approximately 25% (Johnson and Christensen, 1935). A single gall between the ear and the tassel reduced yield approximately twice as much as a gall between the base of the plant and the ear. Yield was reduced ≈50% on plants that had multiple galls. Johnson and Christensen also reported large galls reduced yield more than small galls. Our results demonstrate that modern sweet corn hybrids respond similarly to field corn when infected by common smut.

Billett and Burnett (1978) found that increased dry weight of common smut-infected tissue was accompanied by a decrease in weight of other developing plant parts. As infection advanced, leaf development was delayed and leaf area was reduced. Dry weight reduction, however, was proportionately larger in the root than the shoot. The growth of the gall creates a sink for sucrose and other nutrients exported from photosynthetically active cells (Biemelt and Sonnewald, 2006). More recently, Horst et al. (2008) demonstrated that the establishment of C_4 metabolism is prevented in common smut-infected leaf tissue, which would reduce the photosynthetic efficiency of the affected tissue.

Many of the year × planting date interactions in this data set occurred when ears of the first planting in 2003 were larger than in the second planting. Typically, ears of sweet corn planted in June will be larger than from corn planted in May, but in 2003, extreme heat prevented the June planting from developing larger ears. The average temperature for June, July, and August was 28.6 °C in 2002 and 31.0 °C in 2003. Not only was 2003 a hotter summer than 2002, but from 20 July 2003 to 1 Aug. 2003, the maximum temperature in Hermiston averaged 36.7 °C. This extreme heat occurred at the time the second planting was in the vegetative stage of development between planting and silking. According to Hortik and Arnold (1965), when the air temperature exceeds 29 °C, there is a reduction of vegetative growth. This explains reductions in ear quality measurements at the time of harvest maturity in the second planting of 2003.

Other interactions were the result of lack of galls at some locations with some cultivars, limited number of plants with galls on the upper stalk, and lack of galls in all size categories (primarily galls larger than 10.2 cm) at all locations (Table 9). Relying on natural infection and the limited number of plants to sample at the HAREC location (210/plot) resulted in a wide range of sample sizes and unequal distribution of gall location and size. A more uniform, although still somewhat skewed sample size was obtained from the commercial production fields, where there was a greater number of plants available for sampling. In general, more plants were found to have galls on the lower stalk, followed by the tassel, with the greatest percentage of galls less than 5.1 cm in diameter.

Data from the field trials and the commercial fields were similar. Quality characteristics were reduced by a gall on the base or tassel of the plant, but the greatest impact occurred when the gall was on the upper followed by the lower stalk of the plant. The larger the gall size, the greater the impact on ear quality.

All three of the sweet corn cultivars used in this study were susceptible to common smut, although some data collected would suggest that 'Supersweet Jubilee' was more susceptible or impacted more severely by infection (Clough et al., 2002, 2003). With the lack of fungicides that are efficacious in controlling this disease, other means of disease management such as cultivar resistance may be an important component in the future. Information assessing the relative susceptibility of sweet corn cultivars is needed, particularly their response to this disease in the Columbia Basin of Oregon and Washington.

Table 7. 'Sheba' sweet corn ear quality as affected by gall location and gall size in *Ustilago maydis*-infected plants, commercial fields in 2003.

	Fresh wt (g)	Diam (cm)	Length (cm)	Kernel depth (cm)
Gall location (L)				
None	291 a	5.15 a	19.3 a	0.96
Base	248 b	5.03 ab	18.6 a	0.95
Lower stalk	213 c	4.87 b	16.8 b	0.90
Upper stalk	126 d	4.24 c	12.1 c	0.76
Tassel	295 a	5.21 a	19.7 a	0.98
	****	*	****	NS
Gall size (cm) (S)				
0	291 a	5.14 a	19.3 a	0.96 a
Less than 5.1	272 a	5.10 ab	18.8 a	0.96 a
5.1–10.2	199 b	4.77 c	16.3 b	0.84 b
Greater than 10.2	209 b	4.88 bc	17.1 b	0.92 a
	**	**	***	***
Interactions				
L × S	*	****	NS	**

****, ***, **, *, NS Significant at $P \leq 0.0001$, $P \leq 0.001$, $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 8. 'Supersweet Jubilee' sweet corn ear quality as affected by gall location and gall size in *Ustilago maydis*-infected plants, commercial fields in 2003.

	Fresh wt (g)	Diam (cm)	Length (cm)	Kernel depth (cm)
Gall location (L)				
None	275	4.64	21.2	0.88
Base	261	4.60	20.7	0.90
Lower stalk	259	4.57	20.4	0.90
Upper stalk	226	4.39	19.8	0.84
Tassel[z]	—	—	—	—
	NS	NS	NS	NS
Gall size (cm) (S)				
0	275 a	4.64 a	21.2 a	0.88
Less than 5.1	269 a	4.62 a	20.6 ab	0.90
5.1–10.2	272 a	4.67 a	21.0 a	0.93
Greater than 10.2	224 b	4.39 b	19.8 b	0.84
	****	*	*	NS
Interactions				
L × S	**	*	*	*

[z]Detasseled before harvest.
****, **, *, NS Significant at $P \leq 0.0001$, $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively. Means followed by different letters are significantly different at $P = 0.05$ (Fisher's protected least significant difference).

Table 9. Percent *Ustilago maydis* infections of sweet corn cultivars by gall location and gall size, Hermiston AREC (2002 and 2003) and commercial production fields (2003).

	Hermiston AREC[z]			Commercial fields[y]		
	Sockeye	Sheba	Supersweet Jubilee	Sockeye	Sheba	Supersweet Jubilee
	Percent					
Gall location						
None	40	44	42	25	24	27
Base	3	7	13	25	24	24
Lower stalk	25	8	28	25	24	24
Upper stalk	1	1	10	0	4	25
Tassel	31	40	7	25	24	—[x]
Gall size (cm)						
0	40	44	42	25	24	27
Less than 5.1	42	35	19	56	46	20
5.1–10.2	11	12	23	11	12	18
Greater than 10.2	7	8	16	8	18	35

[z]Sample size: Sockeye-446, Sheba-292, Supersweet Jubilee-390.
[y]Sample size: Sockeye-119, Sheba-119, Supersweet Jubilee-161.
[x]Detasseled before harvest.
AREC = Agricultural Research and Extension Center.

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