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Control and Management of Common Smut on Corn in the Columbia Basin of Oregon and Washington

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Introduction

Since 1996, the incidence of common smut (*Ustilago zeae*) of sweet corn and field corn in the Columbia Basin has increased from non-detectable levels to infection of most fields throughout the region. Processing losses have been due to increased labor costs for removing smutted ears, new equipment to handle smutted corn, and unacceptable quality of ears to produce cob corn due to product contamination by spores in the wash water. Direct grower losses have occurred due to heavily smutted fields being bypassed (rejected) for harvest.

This research was begun with the following objectives:

1) Screen sweet corn cultivars for resistance to common smut.
2) Investigate effect of planting date on development of common smut.
3) Quantify effect of common smut on processing quality characteristics.
4) Evaluate fungicides for the control of common smut.

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Materials and methods

Planting date/cultivar evaluation: Thirty-four sweet corn cultivars for processing were evaluated for resistance to common smut (Table 1). Plots were seeded May 4 and Jun 13/14, with 4-30' rows/plot, on the Hermiston Agricultural Research and Extension Center. Seed for GH 1829, GH 2298, GH 2385 and GSS

9379 was received too late for inclusion in the first planting. The experimental design was a randomized complete block, with four replications.

Normal commercial production practices were followed. At ear maturity, plant stand was recorded, and the number and location (at base, between base and ear, on ear, between ear and tassel, on tassel) of smut galls was noted for each plant. Some plants had more than one infection location. Data were analyzed with the SAS GLM procedure following arcsine transformation.

Ear quality evaluation: For each planting date, and at optimum moisture, ears were sampled from FX516, Sheba and Supersweet Jubilee plants with either no gall, or only a single gall. Location on plant and size of gall were recorded, and fresh weight, length, diameter and kernel depth of the shucked ear were measured. Data were analyzed with the SAS GLM procedure to determine impact of gall location and size on these important processing characteristics.

Fungicide evaluation: Eleven fungicides were tested, alone and/or in combination, with or without COC at 1% v/v (Table 2), in a series of trials in commercial production fields. Rate, number of applications, timing, and method (aerial, ground, in-furrow) were varied. Data collection and analyses were as previously described.

Results

Planting date/cultivar evaluation: The percentage of plants with smut infections on the base, on the lower stalk between base and ear, on the ear, on the tassel, and the percentage of plants infected overall increased from the first to second planting (Table 3). The different cultivars, however, responded somewhat differently to planting date (Tables 4, 5, 6). The varieties most susceptible to infection of the ear over both planting dates included Jubilee and GH2298 (Table 5). Twenty-one varieties were in the least susceptible group, with the percent infected ears ranging from 5.19% for HMX0395 down to 0.61% for FMX516.

The shrunken 2 (sh_2) and normal sugary (su) genotypes were more susceptible to smut infection at the base, on the lower stalk, and for average percent plants with galls, than the sugary-enhanced (se) genotype (Table 3).

Table 1. Sweet corn cultivars evaluated for resistance to common smut, Hermiston, OR. 2002.

Cultivar	Source
su type:	
1703	Syngenta
1861	Syngenta
Chase	Asgrow
Conquest	Crookham
Eliminator	Crookham
EX08715864	Asgrow
EX08716607	Asgrow
FMX 516	Harris Moran
GH 1829	Syngenta
GH 2298	Syngenta
GH 2385	Syngenta
HMX 0395	Harris Moran
HMX 7384	Harris Moran
Jubilee	Syngenta
Legacy	Harris Moran
sh_2 type:	
ACX 232	Abbott & Cobb
ACX 942	Abbott & Cobb
Crisp n Sweet 710	Crookham
EX08492829	Asgrow
EX08705797	Asgrow
GSS 8388	Syngenta
GSS 9379	Syngenta
HMX 0393s	Harris Moran
HMX 8392s	Harris Moran
Krispy King	Syngenta
Marvel	Crookham
Shaker	Asgrow
Sheba	Asgrow
Shogun	Crookham
Summer Sweet #500 (ACX 405)	Abbott & Cobb
Summer Sweet #610	Abbott & Cobb
Summer Sweet #8100	Abbott & Cobb
Supersweet Jubilee	Syngenta
se type:	
Cinch	Asgrow

Table 2. Fungicides evaluated for control of common smut in commercial production fields of Washington and Oregon, 2002.

Fungicide	Manufacturer
BASF 516	BASF
Folicur	Bayer
Folicur + Flint	Bayer
Headline	BASF
Messenger	Eden Biosciences
Moncut	Gowan
Quadris	Syngenta Crop Protection
Quadris + DMSO	
Stratego	Syngenta Crop Protection
Tilt	Syngenta Crop Protection

Ear quality evaluation: Fresh weight, length and diameter were reduced by galls on the lower stalk, as compared to the check (Table 7). Galls on the upper stalk further reduced these parameters. Galls on the base or tassels did not affect ear quality. As might be expected, the larger the gall size, the greater the impact on ear quality.

Fungicide application: At Mesa, WA, 2 applications of Quadris at 9.2 and 12.3 oz/a and at 9.2 oz/a + DMSO at 0.5% v/v to Supersweet Jubilee resulted in more plants without galls than the untreated check (Table 8). In a second Supersweet Jubilee field in Mesa, Quadris applied twice at 12.3 oz/a also resulted in more plants without galls than the untreated check (Table 9).

However, fungicide treatments, including a single Quadris application at 12.3 oz/a, did not control common smut in Supersweet Jubilee sweet corn, in a Paterson, WA, field (Table 10).

Although there were some difference between fungicide treatments in Jubilee sweet corn at Hermiston, none of the treatments differed from the untreated control (Table 11).

Aerial application of Quadris increased the percent plants without galls in 2 of the 3 commercial fields tested, and decreased the percent plants with galls on the lower stalk, between the brace root and ear (Table 12).

Table 3. Effect of planting date on development of common smut of sweet corn, Hermiston, OR., 2002.

Planting Date	Gall location					
	Base	Base-Ear	Ear	Ear-Tassel	Tassel	Plant
Planting date			*Percent (%)*			
May 4	1.75	10.4	4.10	2.48	12.1	26.4
Jun 13	7.79	21.8	5.99	2.55	28.4	53.0
	****	****	****	NS	****	****
Type						
sh_2	6.66a	15.5ab	4.90	3.03	21.4	40.6a
su	2.70ab	18.8a	5.71	1.85	20.1	42.1a
se	1.53 b	5.8 b	1.71	1.48	16.4	24.6 b
	****	*	NS	NS	NS	*

NS, *, **** Means not significantly different, or significantly different at P#0.05 or P#0.0001, respectively.
Means followed by different letter are significantly different at P#0.05 (Duncans multiple range test).

Discussion

The reduction in fresh weight, length, and diameter associated with galls on the lower and upper stalk demonstrates that the losses due to this disease extend well beyond the direct loss of infected ears for processing. In addition to the loss in yield (10 and 20% fresh weight reduction for lower and upper gall infections, respectively), the smaller ear size may result in significant losses to the processor in terms of useable ears.

The identification of resistant varieties may provide an effective tool to control this disease. Several of the varieties tested had significantly fewer infections than the cultivars most widely planted. However, use of these varieties alone may not provide adequate protection. Quadris still appears to offer promise for chemical control; additional field trials to refine rates and timing are needed as well as looking at the cost effectiveness of their use. Ultimately the use of resistant varieties, combined with fungicide applications and/or different cultural practices may prove to be the best method to reduce disease levels. Because of the potential variation between years and the subsequent differences in disease pressure, and the continual release of new cultivars, this work needs to be repeated.

Table 4. Susceptibility of sweet corn cultivars to common smut infection of the lower stalk, Hermiston, OR, 2002.

Cultivar	Planting date: May 4	Planting date: Jun 13	Average
	Infected plants (%)		
08492829	4.0 efgh	10.0 efgh	7.0 ij
08705797	2.2 gh	12.7 defgh	7.4 ij
08715864	6.7 defgh	8.5 fgh	7.6 ij
08716607	12.8 cd	11.2 defgh	12.0 fghi
ACX 232	11.0 cde	29.2 cd	20.1 defgh
ACX 942	4.4 efgh	13.5 defgh	9.0 ij
Chase	9.2 cdefg	13.7 defgh	11.4 ghij
Cinch	4.6 efgh	6.6 gh	5.6 ij
Conquest	10.6 cdef	12.5 defgh	11.6 ghij
C&S 710	3.5 efgh	22.8 cdefg	13.1 fghi
Eliminator	15.2 c	13.2 defgh	14.2 efghi
FMX 516	2.0 gh	18.2 cdefgh	10.1 hij
GH1829	-	27.7 cde	27.7 cd
GH2298	-	56.1ab	56.1 b
GH2385	-	12.5 defgh	12.5 fghi
GSS 8388	15.5 c	32.1 bc	23.8 cde
GSS 9379	-	63.5a	63.5a
HMX 0393s	3.3 efgh	21.3 cdefg	12.3 fghi
HMX 0395	3.3 efgh	13.4 defg	8.3 ij
HMX 7384	27.4 b	34.5 bc	30.9 c
HMX 8392s	15.2 c	29.7 cd	22.4 cdef
Jubilee	46.1a	49.2ab	47.7 b
Krispy King	16.3 c	26.9 cdef	21.6 cdefg
Legacy	11.3 cde	17.5 cdefgh	14.4 efghi
Marvel	0.1 h	1.7 h	0.9 j
Shaker	2.8 fgh	7.4 gh	5.1 ij
Sheba	1.9 gh	6.1 gh	4.0 ij
Shogun	6.2 defgh	22.5 cdefg	14.3 efghi
SmrSwt 500	2.1 gh	7.0 gh	4.5 ij
SmrSwt 610	9.1 cdefg	33.0 bc	21.0 cdefg
SmrSwt 8100	15.5 c	34.7 bc	25.1 cd
SprSwt Jubilee	29.8 b	27.2 cde	28.5 cd
	****	****	****

**** Cultivar effect significant at P#0.0001.
Means followed by different letters are significantly different at P#0.01 (Duncans multiple range test).

Table 5. Susceptibility of sweet corn cultivars to common smut infection of the ear, Hermiston, OR, 2002.

Cultivar	Planting date: May 4	Planting date: Jun 13	Average
	Infected (%)		
08492829	1.7 ef	5.1 bcd	3.4 cdefgh
08705797	5.2 cdef	9.2 bcd	7.2 bcdef
08715864	3.7 def	11.7 b	7.7 bcd
08716607	4.3 cdef	4.2 bcd	4.3 cdefg
ACX 232	1.7 ef	2.8 cd	2.2 fgh
ACX 942	8.0 cd	8.8 bcd	8.4 bc
Chase	4.3 cdef	2.3 cd	3.3 cdefgh
Cinch	1.9 ef	1.5 d	1.7 gh
Conquest	0.7 ef	2.0 cd	1.3 gh
C&S 710	2.9 ef	10.3 bc	6.6 bcdefg
Eliminator	0.9 ef	0.5 d	0.7 h
FMX 516	0.4 f	0.8 d	0.6 h
GH 1829	-	4.1 bcd	4.1 cdefgh
GH 2298	-	22.4a	22.4a
GH 2385	-	2.9 cd	2.9 defgh
GSS 8388	3.2 def	5.6 bcd	4.4 cdefgh
GSS 9379	-	6.3 bcd	6.3 bcdefg
HMX 0393s	1.8 ef	1.5 d	3.8 cdefgh
HMX 0395	1.1 ef	9.3 bcd	5.2 bcdefgh
HMX 7384	1.7 ef	3.3 bcd	2.5 efgh
HMX 8392s	2.7 ef	4.9 bcd	1.7 gh
Jubilee	18.3a	25.9a	22.1a
Krispy King	8.8 bc	7.4 bcd	8.1 bcd
Legacy	2.3 ef	4.4 bcd	3.3 cdefgh
Marvel	0.9 ef	0.5 d	0.7 h
Shaker	2.1 ef	1.1 d	1.6 gh
Sheba	5.8 cde	4.0 bcd	4.9 cdefgh
Shogun	1.3 ef	5.1 bcd	3.2 cdefgh
SmrSwt 500	12.5 b	7.9 bcd	10.2 b
SmrSwt 610	5.7 cde	1.3 d	3.5 cdefgh
SmrSwt 8100	5.5 cdef	7.4 bcd	6.4 bcdefg
SprSwt Jubilee	5.5 cdef	7.2 bcd	6.3 bcdefg
	****	****	****

**** Cultivar effect significant at P#0.0001.
Means followed by different letters are significantly different at P#0.01 (Duncans multiple range test).

Table 6. Susceptibility of sweet corn cultivars to common smut infection of the upper stalk, Hermiston, OR, 2002.

Cultivar	Planting date: May 4		Planting date: Jun 13		Average	
	Infected plants (%)					
08492829	0.2	f	0.1	ef	0.1	gh
08705797	0.0	f	0.0	f	0.0	h
08715864	3.8	cdef	4.9	c	4.3	c
08716607	5.3	c	2.0	cdef	3.7	cd
ACX 232	0.8	def	1.1	def	1.0	defgh
ACX 942	2.6	cdef	3.9	cde	3.2	cdef
Chase	4.3	cdef	1.8	cdef	3.0	cdefg
Cinch	1.5	cdef	1.5	cdef	1.5	cdefgh
Conquest	0.3	ef	0.2	ef	0.2	gh
C&S 710	1.9	cdef	3.6	cdef	2.7	cdefgh
Eliminator	0.8	def	1.0	def	0.9	defgh
FMX 516	0.1	f	0.4	def	0.3	fgh
GH 1829	-		1.3	cdef	1.3	defgh
GH 2298	-		3.1	cdef	3.1	cdefg
GH 2385	-		0.0	f	0.0	h
GSS 8388	0.2	f	0.4	def	0.3	fgh
GSS 9379	-		0.2	ef	0.2	gh
HMX 0393s	0.1	f	0.8	def	0.5	efgh
HMX 0395	0.5	ef	0.5	def	0.5	efgh
HMX 7384	1.1	def	1.2	cdef	1.1	defgh
HMX 8392s	1.4	cdef	1.3	cdef	1.4	defgh
Jubilee	5.0	cd	1.7	cdef	3.3	cde
Krispy King	16.4a		17.3a		16.9a	
Legacy	1.3	cdef	1.8	cdef	1.6	cdefgh
Marvel	1.7	cdef	4.9	c	3.3	cde
Shaker	0.0	f	0.5	def	0.3	fgh
Sheba	0.0	f	0.9	def	0.4	efgh
Shogun	0.8	def	3.7	efghi	1.0	defgh
SmrSwt 500	1.8	cdef	2.7	cdef	2.3	cdefgh
SmrSwt 610	3.4	cdef	3.7	cdef	3.5	cd
SmrSwt 8100	4.5	cde	4.1	cd	4.3	c
SprSwt Jubilee	9.9	b	13.6	b	11.7	b
	****		****		****	

**** Cultivar effect significant at P#0.0001.
Means followed by different letters are significantly different at P#0.01 (Duncans multiple range test).

Table 7. Effect of gall location and gall size on sweet corn ear characteristics, Hermiston, OR., 2002.

	Fresh weight (oz)	Length (in)	Diameter (in)	Kernel depth (in)
Variety[1]				
FX516	8.9 b	8.23 b	1.78 c	0.31 b
Sheba	10.2a	8.40a	1.90a	0.34a
Supersweet Jubilee	9.7a	8.22 b	1.86 b	0.34a
	****	***	****	****
Gall location				
None	9.9a	8.31a	1.88a	0.34
Base	10.1a	8.31a	1.86a	0.34
Lower stalk	9.0 b	8.11 b	1.78 b	0.32
Upper stalk	8.1 c	7.79 c	1.71 c	0.31
Tassel	9.9a	8.42a	1.84a	0.33
	***	*	**	NS
Gall size (in)				
None	9.9a	8.31	1.88a	0.34a
Small (<2)	9.6ab	8.30	1.82 b	0.32 b
Medium (2-4)	9.5 b	8.24	1.82 b	0.33ab
Large (>4)	8.7 c	8.04	1.73 c	0.31 c
	****	NS	****	****

NS,*, **, ***, **** Effect not significant or significant at P#0.05, P#0.01, P#0.001, or P#0.0001, respectively.
Means followed by different letters significantly different at P#0.05 (Duncans multiple range test).
[1] Variety means of uninfected controls.

Table 8. Fungicide efficacy for control of common smut in Supersweet Jubilee sweet corn, Mesa, Wash, 2002.

Treatment[1]	Rate	Gall location					
		None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a			*Percent plants (%)*			
Untreated		35 c	17	31abc	2	12	15
Folicur	7.2	42 bc	2	35ab	2	11	22
Quadris	9.2	53ab	8	25 bc	3	13	4
Quadris	12.3	62a	5	15 c	4	10	10
Quadris +	9.2						
DMSO	0.25%	52abc	13	23 bc	5	5	10
Quadris +	9.2						
DMSO	0.5%	53ab	10	20 bc	3	10	8
Stratego	10.0	43 bc	3	30abc	5	14	13
BAS 516	14.7	39 bc	12	44a	2	11	4
		*	NS	*	NS	NS	NS

*, NS Treatment effect significant at P#0.05 or not significant, respectively. Means followed by different letters significantly different at P#0.05 (Duncans multiple range test).

[1] Treatments applied with tractor-mounted CO_2 sprayer 47 and 61 days after planting with COC at 1% v/v.

Table 9. Fungicide efficacy for control of common smut in Supersweet Jubilee sweet corn, Mesa, Wash, 2002.

Treatment[1]	Rate	Gall location					
		None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a			*Percent plants (%)*			
Untreated		69 bc	2	19	3	5	7
Folicur	7.2	73abc	2	9	2	4	13
Quadris	12.3	82a	1	13	2	3	3
Stratego	10.0	79ab	3	6	4	4	5
Moncut	16.0	66 c	3	20	7	9	1
Trtmnt A		70 bc	5	16	4	5	4
Headline	12.3	67 bc	4	13	3	11	6
Tilt	4.0	79ab	2	11	4	3	3
		*	NS	NS	NS	NS	NS

*, NS Treatment effect significant at P#0.05 or not significant, respectively. Means followed by different letters significantly different at P#0.05 (Duncans multiple range test).

[1] Treatments applied with tractor-mounted CO_2 sprayer 47 and 61 days after planting with COC at 1% v/v.

Table 10. Fungicide efficacy for control of common smut in Supersweet Jubilee sweet corn, Paterson, WA, 2002.

Treatment	Applic. Rate	Timing	Gall location					
			None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a				*Percent plants (%)*			
Untreated			31	24	31	9	16	7
Messenger	2.25	7/31	28	34	23	5	13	10
Messenger	2.25	7/31,8/19	30	24	38	4	11	8
Messenger	4.5	8/14	37	22	28	7	19	3
Folicur	7.2	8/19	25	24	44	6	12	6
Quadris	12.3	8/19	21	31	43	3	16	4
Stratego	10.0	8/19	26	22	43	2	15	6
Folicur + Flint	3.5 + 3.0	8/19	27	24	47	1	10	6
			NS	NS	NS	NS	NS	NS

[NS] Treatment effect not significant.
[1] Treatments applied with tractor-mounted CO_2 sprayer beginning 37 days (7/31) after planting; all except Messenger applied with COC at 1% v/v.

Table 11. Fungicide efficacy for control of common smut in Jubilee sweet corn, Paterson, WA, 2002.

Treatment	Rate	Timing[1]	Gall location					
			None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz-ai/a				*Percent plants (%)*			
Untreated			60abcd	10	27abc	2	2	5
Quadris IF	1.75	7/02	52 cd	11	29ab	2	2	11
Quadris IF	1.75	7/02		2	11 bc	1	2	6
+ Quadris	2.56	8/02	80a	8	15 bc	2	2	6
Quadris IF	3.5	7/02		2	11 bc	1	2	6
+ Quadris	2.56	8/30	72abc	8	15 bc	2	2	6
Quadris	2.56	8/02	78ab	2	11 bc	1	2	6
Quadris	4.0	8/02	68abcd	8	15 bc	2	2	6
A13705B	2.85	8/30	79a	3	12 bc	1	2	3
Tilt	1.79	8/30	47 d	7	35a	4	2	18
Quadris	2.56	8/30	69abcd	9	16 bc	2	1	5
Quadris	4.0	8/30	50 cd	11	27abc	2	2	13
A13705B	2.85	8/30	61abcd	9	21abc	3	2	7
Tilt	1.79	8/30	55 bcd	12	27abc	3	2	8
Quadris	2.56	8/30						
+ Warrior	0.32	8/30	77ab	6	11 c	1	3	3
			*	NS	*	NS	NS	NS

*, NS Treatment effect significant at P#0.05 or not significant, respectively.
Means followed by different letters significantly different at P#0.05 (Duncans multiple range test).
[1] 7/02 treatments applied in-furrow at planting.

Table 12. Efficacy of Quadris for control of common smut in Supersweet Jubilee sweet corn, Hermiston, Ore., 2002.

Treatment	Gall location					
	None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
			Percent plants (%)			
Site 1						
Untreated	96	1.4	2.3	0.4	0.0	0.0
Quadris	98	1.0	1.0	0.0	0.1	0.0
	NS	NS	NS	NS	NS	NS
Site 2						
Untreated	91	0.6	4.3	1.0	2.4	0.6
Quadris	94	0.3	2.9	0.4	1.6	0.4
	*	NS	NS	NS	NS	NS
Site 3						
Untreated	81	0.4	6.8	3.3	4.0	4.6
Quadris	85	0.8	5.1	2.9	1.8	4.5
	*	NS	*	NS	NS	NS

*, NS Treatment effect significant at P#0.05 or not significant, respectively.

[1] Quadris applied at 8 oz/a by airplane in 7 gpa water on 7/5 and 7/16, with silking on 8/12, 8/15, and 8/15 for Sites 1, 2, and 3, respectively.