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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 of Oregon and Washington has increased from non-detectable levels to infection of most fields throughout the Columbia Basin. The extent of losses due to common smut in sweet corn has not been determined but major damage and loss has been reported by the sweet corn processing industry since that time. 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 Acob@ 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.

In 1999 a new kernel quality issue potentially related to smut infection was confirmed. Reports suggest this symptom was observed in 1998 but was likely misidentified as Fusarium ear rot. Affected kernels have a slight fungal growth; when processed, kernels turn dark, making cob corn into culls. The fungus appears yeast-like in culture but the identity and relationship of this fungus to the overall problem is unknown. In addition, damaged (split, leaky) and/or discolored kernels were found in some ears from fields with smut, primarily in SuperSweet Jubilee. The cause of this disorder is unknown but may be related to smut infection.

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) Evaluate fungicides for the control of common smut.
4) Investigate damaged or discolored kernels in what appears to be ears not infected with corn smut.

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Materials and methods

Planting date/cultivar evaluation: Thirty-five sweet corn cultivars grown for processing in the Columbia basin were evaluated for resistance to common smut (Table 1). Plots were seeded May 1 and Jun 4, with 4-30' rows/plot, on the Hermiston Agricultural Research and Extension Center. 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.

Kernel leak evaluation:
Twenty-five ears from each plot of the second variety evaluation planting were evaluated for "leaky" kernels, by husking and visually rating severity on a scale of 0-5. These ratings were regressed on the percent ear infection data across all varieties, and when sorted by type (su, se, or sh_2) to try to determine if there is a relationship to common smut.

Fungicide evaluation: Nine fungicides were evaluated, alone and/or in combination, with or without COC at 1% v/v (Table 2). Supersweet Jubilee was planted in Plymouth and Mesa WA, and Jubilee was planted at Paterson. Fungicides were applied with a boom sprayer covering 6 rows using 30.7 gpa at tasseling (Plymouth, Paterson) or at silking (Mesa). At the Paterson location an additional application was made two weeks following the first. Data collection and analyses were similar to 2000 except 4-15' rows/plot were evaluated. At additional sites outside of Paterson WA, three fields of Supersweet Jubilee and one of white Supersweet Jubilee were chemigated in wedges, with 0, 1 or 2 applications of Quadris. Data collection and analyses were as above except 4-40' rows/plot were evaluated.

Table 1. Sweet corn cultivars evaluated for resistance to common smut, Hermiston, OR. 2001.

Cultivar	Source
su type:	
1703	Novartis
1861	Novartis
2547	Rogers
Chase	Asgrow
Conquest	Crookham
Dynamo	Harris Moran
Eliminator	Crookham
Elite	Novartis
FMX 516	Harris Moran
HMX 7384	Harris Moran
Jubilee	Novartis
Legacy	Harris Moran
Spirit	Rogers
Stylepak	Harris Moran
sh_2 type:	
ACX 232	Abbott & Cobb
ACX 429	Abbott & Cobb
ACX 904	Abbott & Cobb
ACX 933	Abbott & Cobb
Challenger	Asgrow
Crisp n Sweet 710	Crookham
Diva	Asgrow
GSS-5865	Rogers
HMX 8392S	Harris Moran
Krispy King	Novartis
Marvel	Crookham
Shaker	Asgrow
Sheba	Asgrow
Summer Sweet 500	Abbott & Cobb
Summer Sweet 610	Abbott & Cobb
Summer Sweet 8100	Abbott & Cobb
Supersweet Jubilee	Novartis
Supersweet Jubilee Plus	Novartis
se type:	
Cinch	Asgrow
Climax	Asgrow
2684	Novartis

Table 2. Fungicides evaluated for control of common smut, Paterson, Plymouth and Mesa, WA, 2001.

Fungicide	Manufacturer	Rate/Application
Dividend XL	Syngenta Crop Protection	1.1
Folicur[2]	Bayer	7.2
Quadris[1]	Syngenta Crop Protection	12.3
Stratego	Syngenta Crop Protection	10.0
Tilt	Syngenta Crop Protection	4.0
Quadris+Tilt	Syngenta Crop Protection	2.7, 3.42, 4.12, 12.3 + 4.0
Messenger	Eden Biosciences	2.25
BASF 516	BASF	10.56

[1]Quadris also applied at 6.13 and 9.2 oz/a, and in combination w/Warrior insecticide (Syngenta Crop Protection) at 0.2 pt/a at the Morrow Co. location.
[2]Also applied at 3.5 and 4.5 oz/a in combination w/Flint at 3 and 4 oz/a.

Results

Planting date/cultivar evaluation: The percentage of plants with smut infections on the base, between base and ear, between ear and tassel, on the tassel, and 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). The varieties most susceptible to infection of the ear over both planting dates included Supersweet Jubilee Plus, Supersweet Jubilee, Jubilee, Sheba and 2684 (Table 4). Varieties exhibiting the least percent infected ears over both planting dates were Conquest, FMX516, HMX 7384, Legacy, and Marvel. Overall percentage of plants with common smut infections is presented in Table 5.

The shrunken 2 (sh_2) genotype was most susceptible to smut infection, followed by the sugary-enhanced (se) genotype (Table 3). The normal sugary (su) genotype was least susceptible.

Kernel leak evaluation: Regression analyses of the leak rating on percent infected ears across all varieties was significant at P#0.0001, and also when sorted by type (su, se, or sh_2). The R^2_{adj} for a linear relationship was 0.581, 0.510, 0.696, and 0.626 across all varieties, and for su, se, and sh_2 types, respectively.

Table 3. Effect of planting date and type on development of common smut of sweet corn, Hermiston, OR., 2001.

	Gall location					
	Base	Base-Ear	Ear	Ear-Tassel	Tassel	Plant
			Percent (%)			
Planting date						
May 1	7.2	14.7	4.3	3.0	24.2	42.1
Jun 4	4.8	18.2	4.6	2.1	47.2	56.4
	****	***	NS	****	****	****
Type						
sh_2	8.5a	21.3a	6.1a	3.8a	39.6a	57.1a
se	4.4 b	10.3 b	4.4ab	1.6 b	22.8 b	35.2 b
su	3.1 b	11.5 b	2.3 b	1.1 b	33.4ab	42.2 b
	****	****	****	****	**	****

NS, **, ***, **** Effect of planting date or type not significantly different or different at P#0.01, P#0.001, or P#0.0001, respectively.
Means followed by different letters significantly different at P#0.01 (Duncans multiple range test).

Although not conclusive, these data indicate that there may be a relationship between common smut infection, and the leaky kernel defect.

Fungicide application: In two of three locations, Folicur significantly reduced the percent plants infected with the smut fungus (Table 6, 7). Folicur also reduced the percent plants with infections on the lower stalk (between base and ear) at Plymouth (Table 6). At the Mesa location, Folicur at a reduced rate plus Flint (3.5 + 3 oz/a) and Headline also reduced the percent plants with smut galls (Table 7).

Quadris increased the percent healthy plants in one of three locations (Table 6).

Messenger applied twice at Plymouth WA (Table 6) reduced the percent infected plants and the percent plants with galls on the lower and upper stalk (between ear and tassel).

At Paterson WA, Tilt (Table 8a) significantly reduced percent plants infected and percent plants with galls on the tassel. The percent ears infected was reduced by application of Quadris plus

Tilt (3.4+4 oz/a) and Stratego at that location.

The use of Quadris by chemigation, regardless of one or two applications, did not significantly reduce infection levels (Table 9).

Discussion

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, Folicur and Stratego appear 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. Also, residue tolerances have to be established prior to obtaining a label for use of some of these products in sweet corn. 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 over several seasons.

Table 4. Susceptibility of sweet corn cultivars to common smut infection of the ear, Hermiston, OR, 2001.

Cultivar	Planting date: May 1	Planting date: Jun 4	Average
	Infected ears (%)		
1703	4.3 def	0.7 i	2.5 ghi
1861	7.3 def	4.7 defghi	6.0 efg
2547	2.0 ef	0.0 i	1.0 hi
2684	15.3ab	6.8 bcdefg	11.1 bcd
ACX 232	1.7 ef	2.0 ghi	1.8 ghi
ACX 429	2.9 def	9.0 bcde	6.0 efg
ACX 904	5.0 def	12.0 b	8.5 cde
ACX 933	2.6 ef	4.9 defghi	3.8 fghi
Challenger	6.8 def	9.9 bcd	8.3 cde
Chase	1.9 ef	0.5 i	1.2 hi
Cinch	0.1 f	2.5 fghi	1.3 hi
Climax	1.0 ef	0.5 i	0.7 hi
Conquest	0.1 f	0.0 i	0.1 i
C&S 710	6.3 def	7.5 bcdef	6.9 def
Diva	1.6 ef	1.0 hi	1.3 hi
Dynamo	1.9 ef	0.5 i	1.2 hi
Eliminator	2.7 ef	0.2 i	1.5 hi
Elite	1.7 ef	0.1 i	0.9 hi
FMX 516	0.2 f	0.4 i	0.3 i
GSS-5865	4.0 def	6.5 cdefgh	5.2 efgh
HMX 8392s	3.3 def	1.5 ghi	2.4 ghi
HMX 7384	0.6 f	0.5 i	0.5 i
Jubilee	17.0a	9.9 bcd	13.4 b
Krispy King	8.6 cde	9.5 bcd	9.0 cde
Legacy	0.4 f	0.6 i	0.5 i
Marvel	0.1 f	0.5 i	0.3 i
Shaker	0.3 f	0.9 i	0.6 hi
Sheba	16.4ab	6.8 bcdefg	11.6 bc
Spirit	1.4 ef	3.7 efghi	2.5 ghi
Stylepak	0.9 f	1.4 ghi	1.2 hi
SmrSwt 500	1.1 ef	4.0 efghi	2.6 ghi
SmrSwt 610	1.8 ef	2.2 fghi	2.0 ghi
SmrSwt 8100	4.4 def	10.7 bc	7.5 cdef
SprSwt Jubilee	10.1 bcd	17.7a	13.9 b
SprSwt J Plus	14.1abc	22.0a	18.1a
	****	****	****

**** 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, Hermiston, OR, 2001.

Cultivar	Planting date: May 1	Planting date: Jun 4	Average
	Infected plants (%)		
1703	48.0 cdefghi	93.4ab	70.7 bc
1861	38.3 ghijlkm	87.0abcde	62.6 bcde
2547	17.9 nop	13.5 m	15.7 l
2684	45.7 cdefghij	41.1 hijklm	43.4 fghi
ACX 232	34.6 ghijklmn	59.5 cdefghi	47.1 defghi
ACX 429	64.5 bcd	72.0abcdefgh	68.3 bc
ACX 904	47.0 cdefghij	82.3abcdef	64.7 bcd
ACX 933	43.1 efghijk	75.1abcdefg	59.1 bcdef
Challenger	31.9 hijklmno	54.4 defghij	43.1 fghi
Chase	46.3 cdefghij	75.0abcdef	60.6 bcdef
Cinch	45.9 cdefghij	32.6 ijklm	39.3 ghij
Climax	21.9 lmnop	25.0 jklm	23.4 jkl
Conquest	19.4 mnop	15.0 lm	17.2 l
Crsp n Swt 710	46.2 cdefghij	59.5 cdefghi	52.9 cdefgh
Diva	27.7 jklmno	61.9abcdefghi	44.8 efghi
Dynamo	28.9 ijklmno	33.6 ijklm	31.2 ijkl
Eliminator	44.9 cdefghijk	41.1 hijklm	43.0 fghi
Elite	21.3 lmnop	19.7 klm	20.5 kl
FMX 516	44.6 defghijk	86.1abcde	65.3 bcd
GSS-5865	53.9 bcdefg	60.0 cdefghi	56.9 cdefg
HMX 8392s	58.7 bcdef	75.5abcdefg	67.1 bc
HMX 7384	25.7 klmno	20.7 klm	23.2 jkl
Jubilee	64.4 bcd	49.6 fghijk	57.0 cdefg
Krispy King	84.1a	94.6a	89.4a
Legacy	48.8 bcdefghi	54.6 defghij	51.7 cdefgh
Marvel	12.6 op	30.7 ijklm	21.7 jkl
Shaker	68.1ab	87.6abcd	77.8ab
Sheba	49.9 bcdefgh	88.8abc	69.3 bc
Spirit	5.7 p	33.2 ijlm	19.4 kl
Stylepak	40.2 fghijkl	63.5abcdefghi	51.9 cdefgh
Smmr Swt 500	23.4 lmnop	50.9 fghijk	37.2 hijk
Smmr Swt 610	47.1 cdefghij	74.6abcdef	60.8 bcdef
Smmr Swt 8100	46.7 cdefghij	46.1 ghijkl	46.4 defghi
SprSwt Jubilee	65.1 bc	54.3 efghij	59.7 bcdef
SprSwt J Plus	60.8 bcde	61.0 bcdefghi	60.9 bcdef

****	****	****

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

Table 6. Fungicide efficacy for control of common smut in Supersweet Jubilee sweet corn, Plymouth, WA, 2001.

Treatment	Rate	Timing	Gall location					
			None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a				*Percent plants (%)*			
Messenger	2.25	Aug 1[1]	27 bcd	5	60abc	10	13 bc	2
Messenger	2.25	Aug 10	22 d	3	67a	8	13 bc	1
Messenger	2.25	Aug 1&10	40a	3	46 d	8	7 d	4
Messenger	2.25	Aug 16[2]	24 d	4	64a	10	12 bc	3
Quadris	12.3	Aug 16	33 b	1	55 bcd	9	9 cd	2
Folicur	7.2	Aug 16	30 bc	2	53 cd	10	13 bc	3
Trtmnt A[3]			23 d	6	60abc	9	18a	3
Trtmnt B			23 d	6	64a	12	11 bcd	3
Trtmnt C			26 cd	4	60abc	12	10 bcd	4
Trtmnt D			26 cd	6	59abc	10	14ab	5
Check			23 d	5	63ab	10	12 bc	3
			***	NS	*	NS	NS	NS

*, ***, NS Treatment effect significant at P∃0.05, P∃0.001, or not significant, respectively.

Means followed by different letters significantly different at P∃0.05 (Duncans multiple range test).

[1]Sweet corn 24" tall on Aug 1.

[2]Tasseling on Aug 16.

[3]CBI treatments applied Aug 16, 23, 29, and Sep 6.

Table 7. Fungicide efficacy for control of common smut in Supersweet Jubilee sweet corn, Mesa, WA, 2001.

Treatment	Rate	Gall location					
		None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a			*Percent plants (%)*			
Stratego	10.0	47 d	7	35	10	3	3
Flint	8.0	50 bcd	12	25	9	2	1
Folicur	7.2	59a	5	25	6	4	3
Folicur +	3.5+						
Flint	3.0	60a	6	26	8	3	1
Folicur +	4.5+						
Flint	4.0	57abc	8	30	6	2	2
Quadris	12.3	55abc	11	31	6	2	1
BASF 516	10.6	55abc	10	27	7	4	3
Headline	12.3	58a	8	25	7	5	3
Check		48 cd	7	34	10	4	2
		*	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).

Table 8a. Fungicide efficacy for control of common smut in Jubilee sweet corn, Paterson, WA, 2001.

Treatment	Rate	Gall location					
		None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	oz/a			*Percent plants (%)*			
Quadris	6.2	33abc	13	55	11abc	1	4 d
Quadris	9.2	36abc	12	57	11abc	2	8abcd
Quadris	12.3	28 bc	12	61	11abc	1	9abcd
Quadris + COC[1]	12.3	31 bc	11	61	11abc	1	10abcd
Warrior	3.2	25 bc	10	63	14a	1	15a
Quadris + Warrior	12.3 + 3.2	35abc	10	57	12abc	1	8abcd
Tilt	4.0	46a	9	47	11abc	1	5 d
Quadris + Tilt	2.7 + 4.0	32 bc	12	57	12abc	2	8abcd
Quadris + Tilt	3.4 + 4.0	33abc	10	55	9 bc	1	9abcd
Quadris + Tilt	4.1 + 4.0	35abc	14	53	12abc	2	8abcd
Stratego	10.0	38ab	12	53	8 c	1	7 bcd
Folicur + COC[1]	7.2	23 c	10	62	14a	2	12abc
Trtmnt E		33abc	11	56	11abc	1	5 cd
Trtmnt F		22 c	12	70	14ab	1	9abcd
Check		25 bc	11	65	14a	1	13ab
		**	NS	NS	*	NS	*

*, **, NS Treatment effect significant at P≤0.05, P≤0.01, or not significant, respectively.

Means followed by different letters significantly different at P≤0.05 (Duncans multiple range test).

[1]COC at 1% v/v.

Table 8b. Effect of application frequency on fungicide efficacy for control of common smut in Jubilee sweet corn, Paterson, WA, 2001.

	Gall location					
Applications	None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
			Percent plants (%)			
Check	24.6	11.2ab	64.9a	14.2a	1.3	12.9
1	29.9	13.5a	52.7 b	9.4 b	1.0	7.6
2	34.2	8.9 b	62.6a	13.4a	1.4	9.0
	NS	****	***	****	NS	NS

NS Treatment effect not significant.

Table 9. Effect of Quadris chemigation on development of common smut of sweet corn, Paterson, WA, 2001.

		Gall location					
Treatment	Applications	None	Base	Base-Ear	Ear	Ear-Tassel	Tassel
	no			*Percent plants (%)*			
Check	0	60	6	25	8	7	1
Quadris	1	69	2	23	7	3	1
Quadris	2	64	4	22	8	4	1
		NS	NS	NS	NS	NS	NS

NS Treatment effect not significant.