Fusarium Head Blight Occurrence and Effects on Sorghum Yield and Grain Characteristics in Texas

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ABSTRACT

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Fusarium head blight (FHB), caused by *Fusarium moniliforme*, occurred on grain sorghum grown throughout central and southern Texas in 1979. Disease surveys determined that 43 and 91% of the fields (600,000 ha) in central and southern Texas, respectively, had plants with symptoms. Weight and size of kernels from FHB panicles were significantly reduced, compared with kernels from normal-appearing panicles. Kernel weights were reduced an average of 12% (ranging from 4 to 22%) in southern Texas. FHB did not reduce the quality of harvested grain, but based on estimated yield figures, FHB probably reduced yield in Texas by 32,000–78,000 t and resulted in a $3.2 million to $7.2 million loss to farmers.

Additional key words: *Gibberella fujikuroi*, grain molds, grain weathering, *Sorghum bicolor*

Fusarium head blight (FHB), caused by *Fusarium moniliforme* Sheld. (3,7,8), occurred widely on grain sorghum (*Sorghum bicolor* (L.) Moench) hybrids grown throughout central and southern Texas in 1979. Symptoms included necrosis of part to all of the peduncle, rachis, and rachis branches, often with reddening of the pith tissues in affected areas. External reddening affected the rachis branch, rachis, and peduncle tissues frequently and the rachis branch axils occasionally. Drooping of the rachis branches was seen only in fields where harvest was delayed. The widespread occurrence of FHB suggested that it may have affected yield.

This study was undertaken to determine the prevalence of FHB and to estimate its effect on 1979 grain sorghum production in central and southern Texas.

MATERIALS AND METHODS

Five counties in southern Texas were surveyed on 17 and 23 July, and four counties in central Texas were surveyed on 23 August 1979. These nine counties are representative of the sorghum production areas in southern and central Texas and account for about 20% of the 900,000 ha harvested and about 25% of the total production (2.4 million t) in the two areas.

Twenty-six farmers' fields were randomly chosen for sampling; road distance between fields averaged 17 mi in southern and 8 mi in central Texas. FHB occurrence and an estimate of the percentage of plants with FHB symptoms were recorded in each sampled field. Normal-appearing and FHB panicles

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(15–20 each) were randomly collected from the same areas of fields. The percentage of necrotic rachis tissue was estimated for each panicle and all peduncles were evaluated for basal reddening of pith tissues, 10–15 cm below the panicle, before threshing. Grain was threshed separately from the top and bottom half of each panicle to assess the effects of disease on early and late formed kernels.

Grain moisture contents of samples from three locations in central Texas were determined gravimetrically by placing grain in drying ovens at 55 C for 2 days. Grain moisture determinations were not made on southern Texas samples.

Measures of grain quality, including kernel weight, kernel rating on a scale of 1 to 5, preharvest sprouting, and kernel viability, were determined on three 100-kernel subsamples from the southern Texas normal and FHB samples. Preharvest sprouting was based on the percentage of kernels with a split in the pericarp above the embryo; frequently, the elongated cleoptile and coleorhiza had pushed through the pericarp. Kernel viability was measured using the rolled towel method with towels placed in an incubator held at 28 ± 1 C with fluorescent lighting for 12 hr/day for 5 days. In addition, total grain weight and test weight (weight/volume) were recorded for each southern Texas sample. Test weight was estimated by weighing three 28 cm^3 samples of grain and extrapolating the values to kg/hl. Rachises were split after threshing to determine the percentage of panicles with reddened pith tissues.

Fungal incidence in the grain, an additional measure of grain quality, was determined by identifying and counting fungal colonies growing from surface-sterilized kernels. Kernels were surface-sterilized by soaking in 1% NaOCl for 5 min and rinsing in sterile distilled water. The kernels were plated on potato-dextrose agar containing 5 mg/L of benomyl (PDAB) and on Nash and Snyder agar (NSA). PDAB is semiselective for many Dematiaceous fungi, including species of *Alternaria* and *Curvularia*. NSA is selective for *Fusarium* spp. and at least one unidentified species of *Cylindrocarpon*. Plates were incubated at 28 ± 1 C with fluorescent light for 12 hr/day for 7 days. The fungi growing from kernels were identified after 4 days on PDAB and 7 days on NSA.

Data from the top and bottom half samples were pooled for normal and FHB panicles. Paired *t* tests were performed on the data collected from normal and FHB samples. Correlation coefficients were calculated using all variables before and after pooling.

RESULTS

FHB was found in 43 and 91% of the fields surveyed in central and southern Texas, respectively. Roughly 600,000 ha were affected. The average incidence of FHB, based on necrotic rachis tissue, was 26 and 27% in central and southern Texas, respectively. However, the incidence in some fields approached 100% in both areas. The average necrotic rachis tissue on panicles with FHB was 80% in central and 71% in southern Texas.

Reddening of the lower peduncle pith tissue was significantly greater on FHB panicles (32%) than on normal panicles (17%) in southern Texas, but there was little reddening of these tissues on diseased or normal panicles (3 and 1%, respectively) in central Texas. Internal reddening of rachis tissues was significantly greater in FHB panicles than in normal panicles collected in both areas of the state; 64 and 72% of the panicles with external symptoms of FHB had reddened pith tissues in central and southern Texas samples, respectively. Panicles appearing normal externally had 3 and 29% internal reddening in central and southern Texas samples, respectively.

Grain moisture content at harvest was significantly lower with FHB panicles (10.4%) than with normal panicles (13.0%).

Table 1 summarizes the data on quality of threshed grain. Among variables measured on grain from FHB and normal panicles, only differences in kernel weight

Table 1. Mean values of variables on grain with Fusarium head blight and normal panicles collected at 11 locations in southern Texas in 1979

	Head blight panicles			Normal panicles			Calculated
Variables	**Top**	**Bottom**	**Mean**[a]	**Top**	**Bottom**	**Mean**[a]	***t*-value**[b]
Grain weight (g)	21.0	11.7	32.7[c]	22.2	12.0	34.2[c]	−0.946
100 kernel weight (g)	2.7	2.4	2.6	3.0	2.8	2.9	−6.272**
Test weight (kg/hl)	74.9	74.1	74.6	73.9	73.2	73.6	1.351
Small kernels (%)	11.4	47.3	23.5	0.9	10.9	4.6	4.894**
Kernel rating[d]	2.8	2.9	2.9	2.9	3.1	2.9	−0.751
Preharvest sprouting (%)	7.5	4.7	6.6	6.8	4.2	5.9	0.686
Kernel viability (%)	89.4	88.0	88.9	89.8	87.9	89.2	−0.181
F. moniliforme (%)	5.1	10.6	7.3	5.1	9.1	6.7	0.456
F. semitectum (%)	32.1	33.7	32.7	27.3	25.5	26.5	1.274
Curvularia spp. (%)	28.2	23.6	26.5	29.4	24.8	27.7	−0.802
Alternaria spp. (%)	75.5	74.8	75.3	76.1	80.3	77.7	−0.853

[a] Mean is weighted based on proportion of total grain in the top and bottom samples.
[b] Significance of *t*-value is indicated at $P = 0.01$ (**) with 10 degrees of freedom.
[c] Mean total grain weight per panicle.
[d] Based on 1 to 5 scale: 1 = normal appearance of grain, 5 = badly discolored, spotted, or molded (> 10% of the kernels) grain.

Table 2. Correlation coefficients[a] for variables from grain samples from Fusarium head blight and normal-appearing panicles collected in southern Texas in 1979

Variables	**Internal reddening**[b]	***F. semitectum***[c]	***F. moniliforme***[c]	***Curvularia* spp.**[c]	***Alternaria* spp.**[c]	**Viability**	**Sprouting**	**Kernel rating**	**Small kernels**	**Test weight**	**Kernel weight**
Yield (g)	0.07	−0.12	0.01	−0.02	0.08	0.21	0.00	−0.25	−0.52**	0.22	0.54**
Kernel wt (g)	−0.44	0.00	0.03	0.06	0.07	−0.21	0.20	−0.24	−0.64**	0.26	
Test wt (kg/hl)	0.07	−0.41**	−0.13	−0.60**	0.52**	0.22	−0.13	−0.55**	−0.18		
Small kernels (%)	0.60**	0.10	−0.02	0.11	−0.17	−0.17	0.09	0.30			
Kernel rating[d]	0.24	0.17	0.08	0.47**	−0.37*	−0.46**	0.21				
Sprouting (%)	−0.12	0.44**	0.15	0.35*	−0.31*	−0.50**					
Viability (%)	−0.03	−0.38*	−0.09	−0.64**	0.55**						
Alternaria spp. (%)	0.02	−0.34*	−0.19	−0.87**							
Curvularia spp. (%)	0.02	0.25	0.06								
F. moniliforme (%)	−0.09	0.11									
F. semitectum (%)	0.02										

[a] Significance is indicated at $P = 0.05$ (*) and $P = 0.01$ (**); n = 44.
[b] n = 20.
[c] Fungal incidence of grain.
[d] Based on 1 to 5 scale; 1 = normal appearing grain, 5 = badly discolored, spotted, or molded (> 10% of the kernels) grain.

and small kernels were statistically significant. The mean 100 kernel weight from FHB panicles was 2.6 g compared with 2.9 g for 100 kernels from normal panicles, a reduction of 12% (range, 4–22%).

The percentage of small kernels was significantly greater with grain from FHB panicles than with grain from normal panicles. An average of 23.5% of the kernels from FHB panicles were reduced in size compared with only 4.6% of the kernels from normal panicles. FHB and normal panicles, averaged together, had a greater percentage of small kernels on the lower halves of the panicles (29%) than on the upper halves (6%). There were no significant differences between FHB and normal panicles in the incidence of specific fungi in the grain. *Alternaria* spp. were the most prevalent fungi, followed in descending order by *Fusarium semitectum* Berk. & Rav., *Curvularia* spp. (primarily *Curvularia lunata* (Wakker) Boed. and *Curvularia protuberata* Nelson), *F. moniliforme,* and *Helminthosporium* spp.

Correlation coefficients (r) for 12 variables are shown in Table 2. Internal reddening of the rachis was significantly correlated with small kernels (r = 0.60). Kernel weight and small kernels were not significantly correlated with incidence in grain of any of the measured fungi. Test weight was significantly correlated with kernel rating (r = −0.55) and incidence of *Alternaria* spp. (r = 0.52), *Curvularia* spp. (r = −0.60), and *F. semitectum* (r = −0.41).

Yield loss to FHB was estimated from the 1979 survey data in an effort to determine the monetary loss to Texas farmers and the relative importance of FHB compared with other sorghum diseases. Estimated percent loss was calculated by multiplying the proportion of fields where FHB was found by the average proportion of plants diseased and the average percent reduction in kernel weight (eg, $0.91 \times 0.27 \times 12 = 2.9\%$).

The estimated loss from FHB in 1979 was 1.3 and 2.9% in central and southern Texas, respectively. The estimated sorghum grain production for areas of Texas where FHB occurred was 2.45 million t (96.4 million bu). Therefore, the estimated loss in yield would be about 32,000–78,000 t (1.27 million to 2.88 million bu). Assuming that the average price paid for grain was $98.42/t ($2.50/bu), this would amount to a $3.2 million to $7.2 million loss to Texas farmers.

DISCUSSION

FHB appears to have significantly reduced the size and weight of sorghum kernels in southern Texas during 1979. The reductions in 100 kernel weight from 11 locations ranged from 4 to 22%. Other characteristics of grain quality, such as kernel viability, test weight, appearance, sprouting, and fungal incidence, were unaffected by *F. moniliforme* colonization of the rachis branch, rachis, and peduncle tissues. A reduction in kernel filling could result in an earlier than normal maturity and an earlier loss of moisture from kernels. The reduced moisture content of grain from FHB panicles at harvest would support this hypothesis.

FHB had no effect on test weight, sprouting, viability, and fungal incidence. However, fungal incidence was related to test weight and viability (Table 2). Test weight probably was reduced by *F. semitectum* and *Curvularia* spp. colonization of mature grain during periods of rain, which occurred in several areas of southern Texas in 1979. These periodic rains could have favored preharvest sprouting also. Viability of kernels probably was reduced by sprouting and colonization of grain by *F. semitectum* and *Curvularia* spp. *Alternaria* spp. were the most common fungi in the sorghum grain. Typically, the incidence of *Alternaria* spp. is high on normal-appearing grain (1). This observation is supported by the high positive correlation between *Alternaria* spp. and viability percentages and the high negative correlation between *Alternaria* spp. and kernel discoloration (rating).

This study indicates that a significant yield reduction can be caused by FHB even though harvested grain is normal in appearance. In many cases, symptoms of FHB could be overlooked; eg, necrosis of peduncle, rachis, and rachis branch tissues could look like normal senescence of these tissues. However, FHB can be distinguished from senescence by reddened pith and culm tissues. Pith tissues in the rachis and peduncle do not always redden and may appear similar to colonization of these tissues by *Colletotrichum graminicola* (Ces.) Wilson (7). Necrosis of peduncle and rachis tissues is a more obvious symptom of FHB than rachis branch necrosis. However, yield reductions could easily be as great or greater when only the rachis branches are affected.

F. moniliforme can cause a seedling blight, stalk rot, head blight, and grain mold of sorghum, which typically do not occur together (3–6). There is growing evidence that they should be considered separate diseases (1,2,6,7). Isolates of *F. moniliforme* from seedlings, stalks, peduncles, and grain are morphologically similar but may differ physiologically (3). The differential colonization of plant tissues also could be explained by differences in the point of infection (3,5,8), time of infection (1,3,4,7), and host physiology, which could be influenced by environment or host maturity.

Currently, the most practical and economical means of controlling FHB is through the use of resistant hybrids and varieties. Ninety-one percent of the fields surveyed in five counties in southern Texas had varying levels of FHB. This indicates that many U.S. commercial hybrids are susceptible to head blight caused by *F. moniliforme.* Experimental lines need to be tested to determine the susceptibility of these lines to the FHB pathogen and to insure that adequate levels of resistance are present in hybrids and varieties developed for use in the United States and other areas of the world.

LITERATURE CITED

1. CASTOR, L. L., and R. A. FREDERIKSEN. 1980. Fusarium and curvularia grain molds in Texas. In: Proc. Int. Workshop on Sorghum Dis. Dec. 11-15, 1978, Hyderabad, India. In press.
2. EDMUNDS, L. K., and N. ZUMMO. 1975. Sorghum diseases in the United States and their control. U.S. Dep. Agric. Handb. 468. 47 pp.
3. FREDERIKSEN, R. A., D. T. ROSENOW, and J. M. WILSON. 1973. Fusarium head blight of sorghum in Texas. Pages 33-36 in: Proc. Eighth Biennial Grain Sorghum Res. and Utilization Conf. Feb. 27-Mar. 1, 1972, Lubbock, TX. 100 pp.
4. TARR, S. A. J. 1962. Diseases of sorghum, sudangrass, and broomcorn. Commonw. Mycol. Inst., Kew, Surrey, England. 380 pp.
5. TULLIS, E. C. 1951. *Fusarium moniliforme*, the cause of stalk rot of sorghum in Texas. Phytopathology 41:529-535.
6. WILLIAMS, R. J., and K. N. RAO. 1980. A review of sorghum grain molds. In: Proc. Int. Workshop on Sorghum Dis. Dec. 11-15, 1978, Hyderabad, India. In press.
7. WILLIAMS, R. J., R. A. FREDERIKSEN, and J. C. GIRARD. 1978. Sorghum and pearl millet disease identification handbook. International Crops Research Institute for the Semi-Arid Tropics. Information Bull. 2. 88 pp.
8. ZUMMO, N., and R. A. FREDERIKSEN. 1973. Head blight of sorghum in Mississippi, 1972. Page 37 in: Proc. Eighth Biennial Grain Sorghum Res. and Utilization Conf. Feb. 27-Mar. 1, 1972, Lubbock, TX. 100 pp.