Fusarium Scab of Irrigated Wheat in Central Washington

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ABSTRACT

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A survey for scab caused by *Fusarium* spp. was conducted in central Washington by sampling 107 wheat fields. *F. graminearum, F. culmorum, F. nivale,* and *F. avenaceum* incited scab in irrigated fields, but *F. graminearum* was most prevalent. Scab was not found in dryland (nonirrigated) fields. Scab was more prevalent in fields under center-pivot irrigation and most severe in the centers of those fields. The percentage of infected heads in fields ranged from a trace to 89%. Of the fields with scab, 76% had plants with 4% or fewer of their heads infected. *Fusarium* from scabbed heads occasionally invaded the culm, causing discoloration in both field and greenhouse.

Fusarium scab (head blight or tombstone) of wheat (*Triticum aestivum* L.) in Washington was reported to be incited by *Gibberella avenacea* Cook in 1967 (1), *Monographella nivalis* (Schaffnit) Müller (syn. *Calonectria nivalis* Schaffnit) in 1981 (4), and *G. zeae* (Schw.) Petch in 1982 (5). The occurrence of *G. zeae* caused particular concern because of the high toxin content of infected wheat and thus increased the potential seriousness of this disease because of increasing corn acreage in central Washington where wheat is grown under sprinkler irrigation. Surveys were conducted in 1983 and 1984 to evaluate the relative incidence of Fusarium scab of wheat in relation to irrigation and cropping rotations.

MATERIALS AND METHODS

In 1983 and 1984, 132 irrigated wheat fields and 35 nonirrigated fields in central Washington were sampled. Of the irrigated fields, 93 were center-pivot systems, 25 were wheel lines, 12 were rill-irrigated, and 2 were hand lines.

In fields under center-pivot irrigation, five samples, each consisting of the wheat in an area 30 × 30 cm were collected at approximately 88-m intervals (less in smaller fields) on a line extending from the center to the edge of each field. In dryland fields or fields irrigated by other than center-pivot systems, five samples were collected equidistantly on a line through the field.

The percentage of heads infected by *Fusarium* in each sample was determined by the presence of *Fusarium* conidia. Species identification was based on cultures of these spores on carnation leaf agar and potato-dextrose agar, using the methods and synoptic keys of Nelson et al (6). Selected cultures of the *Fusarium* species associated with head blight in Washington were sent to the Fusarium Research Center at Pennsylvania State University for confirmation of identification.

The most severely affected portion of a field was usually around the pivot of the sprinkler system. Seven fields were intensively sampled to determine the extent of this severely diseased area. Measurements were made by collecting samples of wheat heads at points along two to four random lines away from the center pivot. When fewer than 50% of the

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Table 1. Frequency and severity of scab in fields of wheat in relation to irrigation

Type of irrigation	Number of fields sampled	Fields with[a] F.g.	F.c.	F.n.	F.a.	Av. percentage of infected heads per field	Probability of finding scab in a field (%)
Center pivot	93	50	21	6	1	6.3	81
Wheel line	25	6	6	1	0	0.8	48
Rill	12	2	3	0	0	0.4	42
Hand line	2	0	0	0	0	0.0	0
None (dryland)	35	0	0	0	0	0.0	0
Totals							
Irrigated	132	58	30	7	1		
None (dryland)	35	0	0	0	0		

[a] F.g. = *Fusarium graminearum*, F.c. = *F. culmorum*, F.n. = *F. nivale*, and F.a. = *F. avenaceum* (more than one species may occur in same field).

heads in each sample showed symptoms or signs of Fusarium scab, that point was designated as the edge of the severely affected zone. The area of this zone was then calculated.

Isolates were tested for pathogenicity in the greenhouse by inoculating three spring wheat cultivars (Dirkwin, Fielder, and Wared) with a conidial suspension. A 0.05-ml suspension of 6,000 spores per milliliter in glass distilled water containing one drop of Tween 20 per liter was injected with a hypodermic syringe into two spikelets in the middle of the head at anthesis. Control plants were injected with distilled water containing one drop of Tween 20 per liter. The relative humidity was held at 90% or more with a mist system for 24 hr after inoculation, then allowed to drop and fluctuate around 55%. The temperature ranged from a high of 24 C during the day to a low of 15 C at night. Fourteen days after inoculation, the diseased spikelets in each head were counted.

A bluish black discoloration was observed to extend down the culm from diseased heads in greenhouse-inoculated plants and field samples. This culm discoloration had not been described previously. To evaluate the occurrence and extent of the discoloration, a study was conducted by comparing cultivars with varying degrees of scab resistance (Nyu Boy, Nobeoka Bozu, Pel 73081, Pel 73007, and Pel 72393) with Dirkwin. Macroconidial suspensions of three isolates of *F. graminearum* Schwabe and one isolate of *F. culmorum* (W. G. Smith) Sacc. were used to inoculate the six wheat cultivars by previously described methods. Each treatment (isolate) was applied to the plants in seven pots (three plants per pot) of each cultivar. Two pots of each cultivar served as a control. Extent of culm discoloration was measured 20 days after inoculation. The discolored portion of the culm plus 6 cm beyond the discoloration was cut into 3-cm pieces and placed on acidified cornmeal agar to determine the extent of colonization. The mycelium and spores that grew from the stem pieces were examined and cultured to confirm the presence of *Fusarium*.

Table 2. Relative prevalence of the *Fusarium* spp. inciting scab

Fusarium spp.	No. fields	Av. percentage of infected heads per field	Relative prevalence (fields × %)
F. graminearum	58	6.74	391
F. nivale	7	7.66	54
F. culmorum	30	1.64	49
F. avenaceum	1	.48	1

RESULTS

Scabbed heads were found in 92 of the 132 irrigated fields (Table 1). Scab was not evident in any of the 35 dryland fields sampled. *F. graminearum* was prevalent, but *F. culmorum, F. nivale* (Fr.) Ces. (now classified as *Microdochium nivale* (Fr.) Samuels & Hallett), and *F. avenaceum* (Fr.) Sacc. were also found.

Infected plants were found in irrigated fields in Grant, Adams, Franklin, Walla Walla, and Yakima counties. *F. graminearum* and *F. culmorum* were distributed throughout central Washington, whereas *F. nivale* and *F. avenaceum* occurred infrequently and were limited in distribution. Seven of the eight fields that yielded *F. nivale* were concentrated north of Pasco in Franklin County. The only other field containing *F. nivale* was located south of Moses Lake in Grant County. *F. avenaceum* occurred once, just north of Pasco during 1983 and 1984. The distribution of the *Fusarium* spp. was consistent in 1983 and 1984.

Fields infested by one *Fusarium* sp. were sometimes clustered together. For example, in 1984 in northwestern Grant County around Quincy, all of the samples yielded *F. culmorum*, whereas just south of this area, along Interstate 90, all of the fields sampled yielded *F. graminearum*. This clustering of fields according to *Fusarium* spp. was also evident near Mattawa in Grant County and north of Pasco in Franklin County.

The percentage of diseased heads in the fields ranged from a trace to 89%. Of the fields with scabby wheat, 87% averaged 8% or fewer infected heads and 76% averaged 4% or fewer infected heads. Most of the severely affected fields yielded *F. graminearum* and had significant amounts of corn debris on the soil surface or in adjacent fields. All but one field with *F. culmorum* and *F. avenaceum* averaged 4% or fewer infected heads. *F. graminearum* was the most prevalent species, followed by *F. nivale, F. culmorum,* and *F. avenaceum* (Table 2). This relative prevalence was consistent in 1983 and 1984.

Fields irrigated with center pivots contained a significantly greater number of infected heads and were more likely to be scabbed than fields irrigated by wheel line or rill (Table 1). Within these center-pivot-irrigated fields, a small zone of highly infected wheat averaging 0.08 ha was found surrounding the pivots. Sporodochia commonly formed on infected heads within this zone but rarely formed on infected heads in the rest of the field or in fields under other types of irrigation.

Some plants artificially inoculated in the greenhouse and some heads naturally infected (scabbed) by *F. graminearum* and *F. culmorum* contained culms discolored immediately below scabbed heads. Further investigation revealed that both *F. graminearum* and *F. culmorum* can attack heads of wheat and spread to the culm, causing a bluish black discoloration. Isolations from diseased material revealed that the *Fusarium* extended at least as far as the discoloration and frequently could be isolated from apparently healthy stem tissue beyond the discolored zone. In 20 severely diseased plants, discoloration of the culm extended an average of 19.6 cm below the head. The more resistant Chinese cultivars (Nyu Boy [NBOY] and Nobeoka Bozu [NBOZU]) had low relative susceptibility ratings compared with the

Table 3. Relative susceptibility to Fusarium scab

Cultivar	Total av. discoloration (cm)	(No. tillers discolored/no. tillers inoculated) × 100 (%)	Relative susceptibility (Av. × %)
NBOZU	4.4	2/79 (3)	13
NBOY	2.0	6/80 (8)	16
Pel 72393	14.2	6/65 (9)	128
Dirkwin	8.2	38/139 (27)	221
Pel 73007	10.2	16/69 (23)	235
Pel 73081	9.8	40/71 (56)	549

Brazilian cultivars (Pel 73007, Pel 73081, and Pel 72393), which also contain some resistance to scab (Table 3). Dirkwin, a Washington cultivar, was found to be more resistant than Pel 73081.

DISCUSSION

F. graminearum is the principal pathogen causing head blight in central Washington, as in the central and eastern United States, Canada, and several other countries (2,3,7). *F. culmorum, F. nivale,* and *F. avenaceum* also incite scab in central Washington.

In the early 1970s, scab incited by *F. graminearum* was either absent or undetectable in central Washington. Scab caused by *F. graminearum* was found after corn production substantially increased during the late 1970s and early 1980s. In Canada, the incidence of head blight on wheat following corn was six to seven times greater than for wheat following wheat, barley, or oats (8). The increased proximal production of corn and wheat is the most likely explanation for the increased incidence of scab incited by *F. graminearum* in central Washington.

Scab incited by *F. nivale* and *F. avenaceum* was uncommon, probably because of the warm summer temperatures in central Washington. *F. avenaceum* and *F. nivale* are favored by lower temperatures than those that favor *F. graminearum* and *F. culmorum* (2).

The percentage of infected heads in fields with scab ranged from a trace to 89%, although the amount of scab in most of the fields was very low. *F. graminearum* and *F. nivale* were the causal agents in the most severely affected fields, which may result from the ability of these fungi to produce ascospores as the main form of primary inoculum. The teliomorphs of *F. graminearum* and *F. nivale* (4) occur commonly in Washington, whereas the teliomorph of *F. avenaceum* (1,2) is rarely found and that of *F. culmorum* (6) has not been reported.

The severity of scab also varied with the type of irrigation. Center-pivot-irrigated fields contained more scab and were more likely to contain scab than wheel-line- or rill-irrigated fields, probably because of moisture. In fields irrigated by center pivots, the section of the sprinkler nearest to the pivot moves very slowly and therefore the soil and plants are wetter and the humidity higher around the pivot. This localization of high humidity favors the release of ascospores, the formation of macroconidia, and infection. Other types of irrigation apparently do not maintain as much moisture and humidity in one area, and consequently, less infection occurs and secondary inoculum is rarely produced. Small, severely infected zones of wheat consisting of about 0.08 ha occurred around the pivots of center-pivot-irrigated fields affected by scab. Sporodochia were commonly found on wheat heads within these zones, permitting splash dissemination of macroconidia and more infection. Lack of moisture was apparently one of the major factors limiting scab in the outer portion of center-pivot-irrigated fields, in fields with other types of irrigation, and in fields without irrigation.

The other major factor limiting scab probably was the amount of primary inoculum (ascospores) present during flowering of the wheat. In one field (field 54), considerable corn debris containing perithecia of *G. zeae* remained on the soil surface, and virtually all of the heads (89% infection) in the field were infected. The heads not infected were on late tillers. However, in center-pivot-irrigated fields where the amount of primary inoculum (ascospores) was limited, infection was concentrated around the pivots and not uniform as in field 54. This suggests that high availability of inoculum will override the effects of limited moisture. The data also suggest that ascospores can be disseminated downwind to adjacent fields, significantly increasing the severity of scab in those fields. Further study is needed to establish the effective distance airborne ascospores of *G. zeae* can travel.

Some of the isolates invaded the culm below infected heads in the greenhouse, causing discoloration as far as 19 cm below the bases of the heads. This bluish black discoloration was also seen in the field, but the culms were not as extensively colonized as in the greenhouse. This extended invasion of the culm in the greenhouse compared with the field was most likely due to differences in temperature, moisture, and the cultivar of wheat. Discoloration of the culm below infected heads has not been described in the literature.

Incidence of scab probably is generally being kept at acceptable levels by burying corn debris, not planting wheat after corn, and rapid drying of irrigated wheat. As the amount of *F. graminearum* increases, or if corn production increases, scab may become more of a problem in irrigated wheat fields. If scab becomes a significant factor in the reduction of grain quality and yield, an integrated program currently recommended for suppression and control of the disease in humid regions may be necessary (8). This integrated program involves crop rotation, tillage, weed control, the use of high-quality seed, fungicidal seed treatments, and possibly, foliar fungicides.

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LITERATURE CITED

1. Cook, R. J. 1967. *Gibberella avenacea* sp. n., perfect stage of *Fusarium roseum* f. sp. *cerealis* 'Avenaceum.' Phytopathology 57:732-736.
2. Cook, R. J. 1981. *Fusarium* diseases of wheat and other small grains in North America. Pages 39-52 in: *Fusarium*: Biology and Taxonomy. P. E. Nelson, T. A. Toussoun, and R. J. Cook, eds. Pennsylvania State University Press, University Park. 457 pp.
3. Dickson, J. G., Johann, H., and Wineland, G. 1921. Second progress report on the Fusarium blight (scab) of wheat. Phytopathology 11:35.
4. Inglis, D. A., and Cook, R. J. 1981. *Calonectria nivalis* causes scab in the Pacific Northwest. Plant Dis. 65:923-924.
5. Inglis, D. A., and Maloy, O. C. 1983. *Gibberella zeae* causes scab on irrigated wheat in eastern Washington. Plant Dis. 67:827-828.
6. Nelson, P. E., Toussoun, T. A., and Marasas, W. F. O. 1983. *Fusarium* Species: An Illustrated Manual for Identification. Pennsylvania State University Press, University Park. 193 pp.
7. Sutton, J. C. 1982. Epidemiology of wheat head blight and maize ear rot caused by *Fusarium graminearum*. Can. J. Plant Pathol. 4:195-209.
8. Teich, A. H., and Nelson, K. 1984. Survey of Fusarium head blight and possible effects of cultural practices in wheat fields in Lambton County in 1983. Can. Plant Dis. Surv. 64:11-13.