Scab of Wheat and Barley in Southern Idaho and Evaluation of Seed Treatments for Eradication of *Fusarium* spp.

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ABSTRACT

Mihuta-Grimm, L., and Forster, R. L. 1989. Scab of wheat and barley in southern Idaho and evaluation of seed treatments for eradication of *Fusarium* spp. Plant Disease 73:769-771.

In 1982 and 1984, unusual, prolonged rainy and cloudy weather during anthesis promoted scab epidemics in sprinkler-irrigated wheat and barley fields in south central and eastern Idaho. Virtually all plants were diseased in affected fields, and estimated yield losses were as high as 50% in some fields. Rill-irrigated fields in the same area had little or no scab, thus indicating the necessity of favorable weather conditions and sprinkler irrigation for scab epidemics to occur in this semiarid region. *Fusarium culmorum* was most frequently isolated from harvested scab-infested grain, which strongly implicates this species as the principal scab pathogen in this region. Other *Fusarium* spp. isolated were *F. acuminatum, F. avenaceum, F. graminearum,* and *F. equiseti.* Koch's postulates were completed for all of these species, corroborating previous reports indicating that the disease is caused by several *Fusarium* spp. Fungicidal seed treatments were evaluated for eradication of seedborne *Fusarium* and prevention of the seed decay and seedling blight phases of the disease; levels of seedborne *Fusarium* were substantially reduced, but this did not result in greater seedling emergence or better stands in a field trial in 1986.

Additional keywords: fungicides, *Hordeum vulgare*, rill irrigation, *Triticum aestivum*

Wheat scab is a serious problem in parts of Canada (17,21,23) and the United States (12,22) but was not reported in southern Idaho until recently (19). In 1982 and 1984, unusual, prolonged rainy and cloudy weather during anthesis promoted scab epidemics in sprinkler-irrigated wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) in south central and eastern Idaho. Virtually all plants were diseased in affected fields, and estimated yield losses were as high as 50% in some fields.

The disease is caused by several species of *Fusarium*, including *F. graminearum* Schwabe, *F. culmorum* (W. G. Smith) Sacc., *F. nivale* (Fr.) Ces., and *F. avenaceum* (Corda ex Fr.) Sacc. (29). *F. graminearum* is the principal pathogen causing wheat head blight and corn ear rot in Canada (23) and the midwestern United States (5), particularly in areas where corn (*Zea mays* L.) is grown in rotation with wheat and barley. Epidemics of scab in Idaho, however, occurred in wheat and barley fields more than 50 km away from the nearest cornfield, which suggests a different etiology.

The objectives of this study included identifying the species of *Fusarium* associated with wheat and barley seed harvested from scab-infested fields and determining the pathogenicity of representative isolates of these species. Since pre- and postemergence damping-off of cereals caused by seedborne *Fusarium* spp. have been directly correlated with the level of seed infestation (2,8,10,14), an additional objective was to evaluate various seed treatments for control of these organisms to prevent the seed decay and seedling blight phases of the disease. A preliminary report of this research has been published (19).

MATERIALS AND METHODS

Species identification. A seed-plating technique was used to determine which *Fusarium* spp. were associated with 12 wheat seed lots and one barley seed lot obtained in 1984 from scab-infested fields in south central and eastern Idaho. In four replications, 25 seeds from each seed lot were placed onto acidified cornmeal agar (ACMA), with five seeds per plate, and maintained at 22–24 C with a 12-hr fluorescent and incandescent photoperiod. The plates were examined after 7 days, at which time *Fusarium*-like colonies were removed, placed onto carnation leaf agar, and incubated under the same conditions, for subsequent identification. After another 10 days, the cultures were examined for sporodochia, and macrospores and hyphae, if present, were examined microscopically. *Fusarium* spp. were identified with keys developed by Nelson et al (20).

Pathogenicity tests. At least 9% of the isolates, representing the five *Fusarium* spp. identified, were tested for pathogenicity. Each single-spore isolate was grown on potato-dextrose agar with a 12-hr fluorescent and incandescent photoperiod at 22–24 C for 7 days. A 1-cm^2 plug of mycelium with conidia from potato-dextrose agar plates of each isolate was used to inoculate 40 ml of carboxymethylcellulose broth (6) in a 250-ml Erlenmeyer flask. The cultures were incubated on a rotary shaker (250 rpm) at 21–25 C with a 10-hr fluorescent photoperiod. After 7–9 days, each liquid culture was strained through one layer of cheesecloth, and spore concentrations were adjusted by means of a hemacytometer to approximately 2.3×10^5 conidia per milliliter. Wheat plants (cultivar WestBred 906-R) were inoculated at anthesis (Feekes growth stage 10.5.2) (16); approximately 10 ml of inoculum was atomized evenly on six heads per isolate. Waxed paper bags were placed over the inoculated spikes. The controls consisted of inoculation with water and a potato pathogen, *F. sambucinum* Fuckel. The test plants were incubated for 2–3 wk in the greenhouse at 20–30 C with a 12- to 14-hr photoperiod, after which they were evaluated for scab symptoms.

To complete Koch's postulates, two symptomatic glumes were removed from each spike, surface-sterilized for 1 min in 0.5% sodium hypochlorite, placed

Table 1. *Fusarium* spp. associated with scab-infected wheat and barley seed harvested in southern Idaho in 1984

Species	Number of isolates	Percentage
F. culmorum	227	76.2
F. acuminatum	55	18.6
F. avenaceum	8	2.7
F. graminearum	7	2.3
F. equiseti	1	0.2
Total	298	100

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This investigation was supported in part by a grant from the Idaho Wheat Commission.

Published as Idaho Agricultural Experiment Station Journal Series Article 88738.

Accepted for publication 5 January 1989 (submitted for electronic processing).

onto ACMA, and maintained at 22–24 C with a 12-hr fluorescent and incandescent photoperiod. The plates were examined after 6 days, at which time possible *Fusarium* colonies were transferred to carnation leaf agar for subsequent identification.

Seed treatment. One barley seed lot (number 2) and two wheat seed lots (numbers 9 and 11) obtained from scab-infested fields in 1984 were subjected to six fungicidal treatments. The seed treatments and amounts of active ingredient per kilogram of seed were imazalil (Nuzone 10ME), 0.05 g, plus TCMTB (Nusan 30EC), 0.25 g; imazalil, 0.05 g, plus TCMTB, 0.16 g; iprodione (Rovral 30), 0.07 g; carboxin, 0.10 g, plus thiram, 0.10 g (Vitavax 200); guazatine (Panoctine 35), 1.05 g; and GUS EC25 (an unidentified experimental product of Gustafson, Inc., Dallas, TX), 2.0 g. Untreated seeds were used as a control.

In four replications, 25 seeds per treatment were plated onto ACMA and incubated as previously described. Each seed was visually evaluated after 6 days, and the number of *Fusarium* colonies was recorded. Microscopic examination of randomly selected isolates confirmed the presence of *Fusarium* spp. Also, in six replications, 100 seeds per treatment were planted in the field on 18 May 1986, in a randomized complete block design. The trial was established on a rill-irrigated field of Portneuf silt loam (18% sand, 61% silt, and 21% clay; pH 7.5; 0.5% organic matter) at the Kimberly Research and Extension Center, Kimberly, Idaho. The mean soil temperatures at 5- and 10-cm depths for the 7 days following planting were 16 and 14 C, respectively. Stand counts were taken 25 days after planting.

RESULTS

Species identification. Thirteen seed lots were examined, and 298 *Fusarium* isolates were cultured from them and identified (Table 1). *F. culmorum* was the most frequently isolated species (76.2%). Other species isolated included *F. acuminatum* Ell. & Ev., *F. avenaceum*, *F. graminearum*, and *F. equiseti* (Corda) Sacc. The seed lots having the most seedborne *Fusarium* spp. were the barley seed lot (number 2) and two wheat seed lots (numbers 9 and 11), in which *Fusarium* spp. were associated with 47, 38, and 51% of the seeds, respectively. Other fungi associated with the seeds included unidentified species of *Alternaria, Penicillium, Epicoccum, Cladosporium, Mucor*, and *Trichoderma.*

Pathogenicity tests. Of the 30 isolates tested for pathogenicity, 24 caused glumes of inoculated plants to become necrotic, as in natural epidemics in the field. *F. culmorum* caused more severe scab symptoms than the other four species tested. Reisolation and comparison of the cultures with isolates from the original diseased tissue indicated that the cultures and original isolates were identical, thus completing Koch's postulates for all five *Fusarium* spp.

Seed treatment. The incidence of seedborne *Fusarium* spp. in the seed lots tested ranged from 38 to 51% in the untreated controls. GUS EC25 was the only treatment that completely eradicated *Fusarium* (Table 2). The other treatments all significantly reduced the amount of seedborne *Fusarium*, compared with levels in the untreated controls. Though differences between treatments existed in the laboratory, stand counts of seedlings from treated seeds were not significantly different from those of the untreated controls (Table 2). No phytotoxicity was observed.

DISCUSSION

Grain is most susceptible to infection by *Fusarium* at anthesis (1,24,29). Continuous surface wetness and warm weather during anthesis favor infection (1,21). Teich and Nelson (25) observed that the absence of wet weather during anthesis resulted in a very low incidence of head scab. In southern Idaho, anthesis occurs in mid-June for winter wheats and late June for spring wheats. Mean annual precipitation in this area is 20–25 cm (8–10 in.), and it seldom rains during the summer. However, in 1982 a trace or measurable amount of precipitation was recorded for 12 of the 16 days in the period 22 June–8 July. Similarly, in 1984 a trace or measurable amount of precipitation was recorded for 12 successive days from 4 to 15 June. This frequent precipitation coupled with sprinkler irrigation provided favorable environmental conditions for the 1982 and 1984 epidemics. Wheat and barley in rill-irrigated fields in the same area exhibited little or no scab, indicating the importance of both sprinkler irrigation and a rainy period for disease development in a semiarid area like southern Idaho.

F. graminearum, F. culmorum, F. avenaceum, and *F. nivale* are all causal agents of wheat scab (8,12,15,17, 21–23,29). Results of pathogenicity tests confirmed earlier reports (8,10) that *F. avenaceum* is a weak parasite. The high frequency of recovery of *F. culmorum* from the harvested seed strongly suggests that this species was the major causal agent of scab in southern Idaho in the 1984 epidemic.

F. culmorum is the main cause of Fusarium foot rot in the northwestern United States (11,12). More than 90% of isolates obtained from diseased culms were *F. culmorum* (11). Host debris from cereal crops with Fusarium foot rot would likely be a primary source of *F. culmorum* inoculum.

F. culmorum causes severe seedling blight, foot and root rot, and a marked reduction in barley and wheat yields (26).

Table 2. Effect of fungicides on seedborne *Fusarium* spp. in wheat and barley seed and on seedling emergence

Treatment and amount of active ingredient per kilogram of seed	Percentage of seed with *Fusarium* spp.[x]				Control (%)	Seedling emergence (%)[y]			
	Seed lot number[z]					Seed lot number			
	2 (B)	9 (W)	11 (W)	$\bar{x}$		2 (B)	9 (W)	11 (W)	$\bar{x}$
GUS EC25 (2.0 g)	—	0 a	0 a	0	100	—	70 a	62 ab	66
Imazalil (0.05 g) + TCMTB (0.25 g)	—	0 a	2 a	1	98	—	59 a	52 b	55
Iprodione (0.07 g)	—	3 a	2 a	3	93	—	67 a	68 ab	67
Carboxin (0.10 g) + thiram (0.10 g)	8 a	1 a	3 a	4	91	71 a	70 a	63 ab	68
Imazalil (0.05 g) + TCMTB (0.16 g)	19 ab	4 a	4 a	9	80	59 a	61 a	53 b	58
Guazatine (1.05 g)	13 a	1 a	24 b	13	71	66 a	65 a	70 a	67
Untreated control	47 b	38 b	51 c	45	—	73 a	61 a	61 ab	65

[x] Four replications of 25 seeds per treatment were plated onto acidified cornmeal agar and incubated under a 12-hr fluorescent and incandescent photoperiod at 22–24 C. Each seed was visually evaluated after 6 days, and the number of *Fusarium* colonies was recorded.

[y] Six replications of 100 seeds per treatment were planted in the field on 18 May 1986, in a randomized complete block design. Stand counts were taken 25 days after planting.

[z] B = barley; W = wheat. Means within seed lots followed by the same letter are not significantly different according to LSD values (P = 0.025) calculated from data transformed to arc sines.

Different strains of *F. culmorum* have been found to differ in virulence (13,26,27). Uoti (27) reported that all strains of this species are somewhat pathogenic and therefore pose a potential danger for seed decay and seedling blight or root rot.

Various seed treatments have been suggested as controls for seed and seedling diseases caused by *Fusarium* spp. (3,4,7,9,14,18,28). Results of the laboratory study of seed treatments indicate that several of these fungicides are effective in reducing the seedborne inoculum of *Fusarium* spp. However, this reduction had no significant effect on the incidence of seed decay and seedling blight under field conditions.

Results of this research support the hypothesis that the etiology of wheat scab in south central and eastern Idaho is different from that in major corn-producing areas. On the basis of the frequency of recovery of different pathogenic species of *Fusarium*, we believe that *F. culmorum* is the major causal agent of wheat scab in southern Idaho. Results of the laboratory study of seed treatments indicate that the levels of seedborne *Fusarium* can be reduced with various fungicides, but this treatment may not result in greater emergence or stands in the field.

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