Fusarium Head Blight in Ethiopian Wheat and the Identification of Species Causing the Disease

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Abstract

Wheat seeds produced in 1987 and stored under various conditions at research centres, seed farms, state farms and farmers' stores in different regions of Ethiopia were checked for *Fusarium* infection. The disease was detected in 35 to 63 percent of the samples. The level of seed infection per sample ranged from 1 to 17 percent. Fusarium head blight (FHB) survey in wheat fields in 1988 indicated up to 85 percent infection in some state farms. Infected spikelets per head ranged from 5 to 80 percent. The high yielding cultivar Dashen, was very susceptible to FHB while 'Enkoy, exhibited significant resistance. There were a few resistant lines identified from the breeding lines in advanced tests in 1988. Considerably low levels of FHB were recorded at farmers' fields than in state farms. Seventeen and thirteen *Fusarium* species were identified from stored seeds and scabby wheat heads in the field, respectively. *F. nivale* and *F. avenaceum* were the dominant species in the field samples collected from cool, moist, high altitude areas whereas *F. graminearum* was more frequent at lower altitudes and northwestern regions. *F. sporotrichoides* and *F. poae*, which are important because of their ability to produce more deadly mycotoxins, were less frequent and more limited in distribution in both state farms and farmers, fields. *F. Avenaceum, F. lateritium* and *F. equiseti* were more commonly isolated from stored seed samples. Results of this study suggest that FHB can be a major threat to wheat production in Ethiopia under high rainfall conditions that are favourable to the disease development.

Introduction

Fusarium head blight, also known as head scab, is a disease that occurs on small grain cereals such as wheat, and distributed worldwide (Wiese 1987). The disease is best recognized on emerged immature heads of wheat where one or more spikelets or the entire head appears prematurely bleached. Superficial pink or orange mycelium and spore masses may be seen on diseased spikelets. Bleached spikelets are often sterile or contain poor quality seed that give rise to seedlings of low vigour (Bechtel et al. 1985, Martin & Johnston 1982). The disease is caused by a number of fungal species in the genus *Fusarium*.

The importance of FHB has significantly increased with the knowledge of mycotoxins produced by the pathogens and the health hazards they present to humans and animals when contaminated grains and grain products are ingested (Christensen 1965, Mirocha & Christensen 1974, Young & Fulcher 1984). In Ethiopia, it is often reported as one of the major wheat diseases in the cool and wet climate high altitude areas (Eshetu 1985). The importance, geographical distribution, and identity of FHB has not been investigated. The purpose of this study was, therefore, to determine the extent of *Fusarium* infection of seeds and FHB in wheat fields, to determine the identity and distribution of the species, and to assess the reaction to the disease of some breeding lines in advanced stage of testing.

Materials and Methods

Detection of Fusarium on Stored Seeds

A total of 301 seed samples were collected from

basic seed production, demonstration fields, seed farms, state farms and farmers' fields in Arsi, Bale, Gojam, Gonder, Shewa and Wollo regions. The seeds were harvested in the 1987 growing season and stored under various conditions. *Fusarium* seed infection was detected by plating 200 surface disinfected (with 70% ethanol and then 1% sodium hypochlorite) seeds per sample on potato sucrose agar (PSA) as described by Booth (1977). The plates were incubated at 20-24°C with 12 h fluorescent light and 12 h darkness for 7 to 10 days. *Fusarium* colonies were identified by the presence of typical conidia.

FHB in wheat fields

FHB surveys were made from September to late November, 1988 on research plots, seed farms, state farms and farmers fields in Arsi, Bale, Gojam, Gonder and Shewa. Plants with blighted and non-blighted heads were counted separately in 0.5 m x 0.5 m quadrants to determine the incidence. Severity of the disease was determined by counting the number of infected spikelets per head. Percentage of shrivelled seeds was determined and seed infection was determined by plating 200 surface sterilized threshed seeds on PSA plates as described earlier.

Breeding lines in advanced tests were also evaluated for their reaction to FHB at Holetta and Kulumsa research centers under natural infection condition.

Identification of Fusarium Species

Single spore cultures were prepared from PSA cultures isolated from both stored seed and field samples as described by Booth (1977). Spore suspensions of such isolates were transferred to silica gel and stored at 4°C as described by Windels et al. (1988). Some grains of the silica gel with spores were spread on PSA plate and stored at conditions stated above. Species identification was made from 7 to 10 days culture using identification keys outlined by Booth (1977) and Nelson et al. (1983). Characteristics of the fungus such as growth rate; presence or absence of microconidia; formation of conidia from simple or polyphialides; shape, septation and size of conidia; and culture pigmentation were considered.

Results and Discussion

Seed Infection

The level of *Fusarium* infection or contamination of stored seed samples is shown in Table 1. *Fusarium* was detected in 35 to 63% of stored seed samples from various sources. There were more seed samples infected from the state farms (63%) and breeder seeds (56%) than the farmers' samples. Seed infection per sample ranged from 1 to 17%. The survey indicated that *Fusarium* infection was higher on hexaploid wheat than on tetraploids. It is interesting to note that basic seeds and seed production samples showed such high level of infection.

Incidence of FHB in the field

Table 2 shows the incidence and severity of FHB at various locations. The incidence of FHB ranged from zero to about 35, 56, 57 and 84% at farmers' fields, experiment stations, seed production fields and state farms, respectively. The disease was more severe at state farms mainly because of the large acreage planted to the susceptible cultivars 'Dashen' and 'Batu'. The incidence of FHB on the variety 'Enkoy' was less than 2% in most state fars. Severity of the disease ranged from zero to 80% (Table 2). Once the head was infected more than 60% of the spikelets were found to be also infected.

At farmers' fields, FHB was recorded only around Holetta and Kulumsa where farmers used improved cultivars such as 'Dashen' The disease was practically absent in most farmers' fields where landraces were used. The crop stage in these areas might have been too early for FHB development, since farmers usually plant their wheat late in the season.

Sowing date did not seem to have a consistent effect on FHB development in the state farms. The disease was more severe on early plated wheat in some state farms while the reverse was true in others (Table 3). Seeds of the susceptible cultivars were mostly shrivelled and germination was highly affected by the disease in some state farms (Table 3).

Weather conditions during the 1988 growing season were unusually conducive to the development of FHB in most wheat producing

Table 1. *Fusarium* infection on stored seed samples in 1987.

Seed source	No. of samples	Samples infected (%)	Seed infection (%)
Breeder Seed			
Hexaploid	25	56	1-17
Teraploid	8	50	1-2
Seed production	16	44	1-3
Demonstration	16	37	1-2
State Farms	19	63	1-13
Farmers	217	35	1-13

Table 2. Incidence and severity of FHB in different wheat fields during the 1988 growing season.

Location	Incidence (%)	Severity (%)	Remarks*
Experiment Centers	0-56	0-80	Kul, Hoi, Adt
Seed Production	0-57	0-60	Kul, Hoi
State Farms	0-84	0-80	Dix, Gof, Lol
Farmers Fields	0-35	0-50	Hoi & Kul area

* *Adt=Adet, Dix=Dixis, Gof=Gofer, Hol=Holetta, Kul=Kulumsa, Lol=Lole.*

regions of the country. Rainfall, for example, was 10 to 135% more than the average during August, September and October in the surveyed areas. The occurrence of continued wetness favours FHB development to become epidemic in proportion (Andersen 1948).

Most of the breeding lines that were evaluated under natural infection at Holetta and Kulumsa in 1988 showed susceptible reaction to FHB (Table 4). Only two lines: 'HAR 727' and 'HAR 424' were better than 'Dashen' which had been observed to be susceptible in the state farms. Result of both the seed infection and FHB field survey indicated that *Fusarium* diseases in general and FHB in particular can be a major problem to wheat production in the country unless the wheat improvement program considers developing resistant cultivars to the disease as one of its objectives.

Fusarium species on stored seeds

Fusarium species and their frequencies identified from stored samples collected from basic seed, seed production, demonstration, state farms, and farmers' stores in different regions are presented in Table 5. Seventeen species were identified; the most frequent species that constituted 10% or more of the isolates were *F. avenaceum, F. lateritium* and *F.equiseti* in basic seed samples; *F. avenaceum* and *F. nivale* in seed production samples; *F. nivale* and *F. semitectum* in the state farm samples; and *F. equiseti, F. graminearum* and *F. nivale* in farmers samples.

F. nivale was most widely distributed as it was isolated from samples of all seed sources. A large number of species were isolated from farmers' samples, particularly from those collected from Arsi and Shewa regions where wheat is grown extensively.

Table 3. Characterization of wheat seeds harvested from severely FHB infected blocks of four state farms during the 1988 season*

State Farm	Variety	Field no.	Plantig date	Inc. (%)	Shr. (%)	Ger. (%)
Dixis	Dashen	C-19	29/5	24	59	83
		C-21	29/5	50	59	82
		C-13	2/6	90	44	86
		B-12	3/6	97	29	89
Gofer	Batu	C-53	4/6	15	32	65
	Dashen	C-47	4/7	71	40	67
		C-44	5/6	77	69	43
		B-28	10/6	95	78	44
Lole	Batu	B-9	11/5	65	23	86
	Dashen	B-A1	1/7	84	42	91
Serufta	Batu	1-34	26/5	82	50	70
		1-15	26/5	91	26	89
	Dashen	2-73	13/6	62	23	78
		1-23	27/5	90	27	85

**Inc.=Incidence; Shr.=shrivelled; Ger.=germinating.*

Table 4. Percent incidence and severity of FHB in advanced breeding lines of wheat at Holetta and Kulumsa Research Centers during the 1988 season.

	Holetta		Kulumsa	
Variety	Incidence	Severity	Incidence	Severity
HAR 727	3 c	10 d	10 f	14 e
HAR 424	8 c	25 bcd	15 f	30 de
HAR 719	12 c	20 cd	25 ef	35 cd
Dashen	25 b	30 bc	16 f	40 bcd
HAR 604	25 b	30 bc	34 dc	30 de
HAR 609	27 b	30 bc	13 f	25 ed
HAR 715	30 b	20 bcd	40 cd	50 b
HAR 627	31 b	30 bc	42 bcd	40 bcd
HAR 720	32 b	35 b	47 bcd	40 bcd
HAR 605	36 b	25 bcd	54 b	30 bcd
HAR 716	38 b	35 b	39 d	40 bcd
HAR 600	65 a	80 a	54 b	65 a
HAR 712	70 a	75 a	69 a	45 bc

**Percentage values with the same letters are not significantly different according to Duncan's multiple range test (P=0.05).*

Table 5. *Fusarium* species and their frequencies in different stored seed samples of the 1987 crop.

Fusarium species	Seed Source[1]				
	BS	SP	DF	SF	FF
F. avenaceum (Fr.) Sacc.	38	50	-	-	1
F. lateritium Nees	31	7	-	-	2
F. equiseti (Corda) Sacc.	10	-	-	-	21
F. nivale (Fr.) Ces.	8	22	25	66	11
F. graminearum Schwabe	5	-	-	4	15
F. heterosporum Nees	3	-	-	-	4
F. oxysporium Schlecht.	1	7	-	-	4
F. poae (Peck) Wollenw.	-	-	38	3	9
F. semitectum Berk. & Rav.	-	-	-	17	7
F. sambucinum Fuckel	-	-	-	-	6
F. solani (Mart.) Sacc.	-	-	-	-	3
F. moniliforme Sheldon	-	-	-	-	2
F. stilboides Wollenw.	-	-	-	-	1
F. tricinctum (Corda) Sacc.	-	-	-	-	<1
F. decemcellulare Brick	-	-	-	-	<1
F. merismoides Corda	-	-	-	-	<1
F. udum Butler	-	-	-	-	<1
Fusarium spp.[2]	4	14	37	10	13

[1]BS=basic (breeder) seed; SP=seed production; DF=demonstration fields; SF=state farms; FF=farmers' fields.
[2]Species could not be identified due to contamination and/or insufficient structural evidence.

Fusarium species from scabbed wheat heads

Fusarium species identified from seeds of scabby wheat heads collected during field surveys in the 1988 season are summarized in Table 6. More species were identified from research centers than from state farms and farmers fields. *F. nivale* was the most frequently identified species, followed by *F. avenaceum* and *F.graminearum*. The distribution and frequency of these species is presented in Figure 1. *F. graminearum* was more prevalent in lower and dryer regions like Debre Zeit and north western regions.

The relative head blighting potential of some of these species have been studied (Stack & McMullen 1985). *F. graminearum* and *F. culmorum* caused sever blighting while *F. nival, F. poae* and *F. sporotrichioides* were also shown to colonize leaves and leaf sheaths prior to emergence of the ear (Inglis & Cook 1981, Struz & Johnston 1983, Vargo & Baumer 1986). *F. culmorum* (W.G. Sm.) Sacc. (Stewart & dagnatcew 1967) and *F. logipes* Wollenw (Awgichew 1982) which were reported previously to occur on wheat in Ethiopia has not been identified during this study.

Table 6. Percentages of *Fusarium* species isolated from scabby wheat heads collected from different sources in the 1988 season.

Fusarium species	Research Centers	State Farms	Farmers' Fields
F. nivale (Fr.) Ces.	48	52	35
F. avenaceum (Fr.) Sacc.	15	37	31
F. graminearum Schwabe	22	2	29
F. poae (Peck) Wollenw.	<1	2	1
F. sambucinum Fuckel	-	2	-
F. lateritium Nees	-	1	1
F. sporotrichioides Sherb.	<1	-	1
F. stilboides Wollenw.	<1	-	-
F. heterosporum Nees	<1	-	-
F. tricinctum (Corda) Sacc.	<1	-	-
F. semitectum Berk. & Rav.	<1	-	-
F. equiseti (Corda) Sacc.	<1	-	-
F. Moniliforme Sheldon	-	<1	-
Fusarium spp[1]	13	8	-

[1]*Species could not be identified due to contamination and/or insufficient structural evidence.*

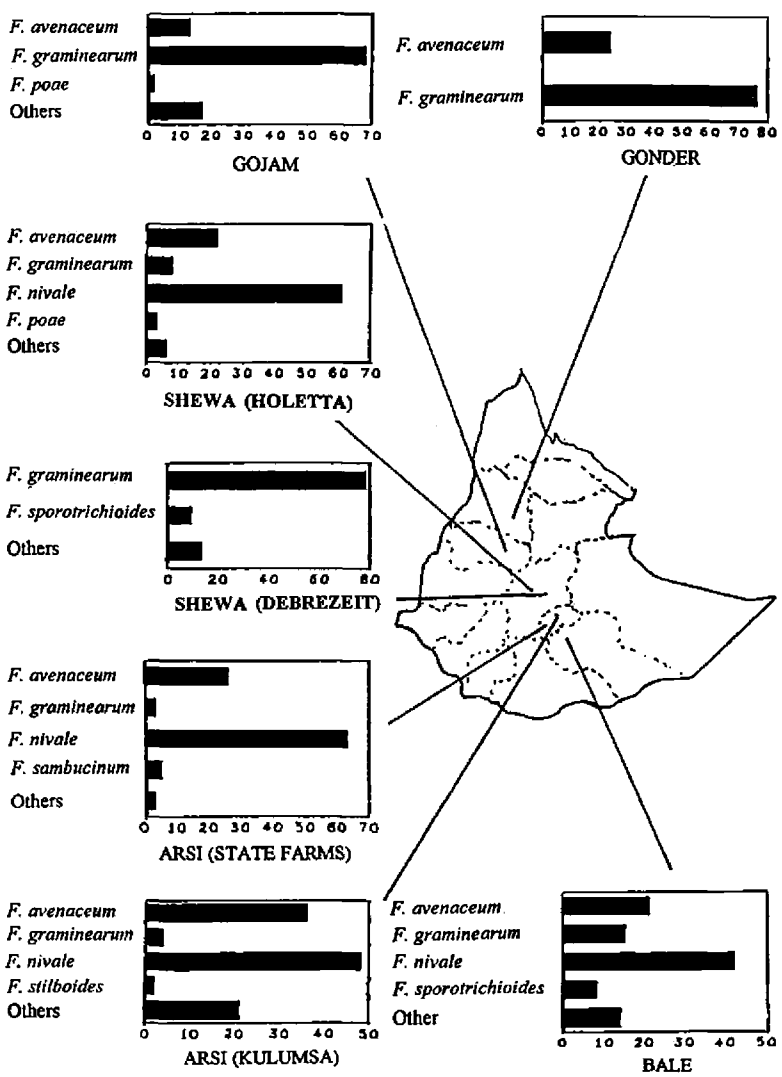

Fig. 1. **Frequencies and distribution of the major *Fusarium* species identified from FHB infected wheats in 1988**

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References

Andersen AL. 1948. The development of *Gibberellazeae* head blight of wheat. Phytopathology **38**:595-611.

Awgichew Kidane. 1982. Additional Index of Plant Diseases in Ethiopia. Institute of Agricultural Research (IAR): Addis Ababa, Ethiopia.

Bechtel DB, Kaleikau LA, Gaines RL, Seitz LM. 1985. The effect of *Fusarium graminearum* infection on wheat kernels. Cereal Chemistry **62**:191-197.

Booth C. 1977. *Fusarium*: Laboratory Guide to the Identification of the Major Species. Commonwealth Mycological Institute: Kew, Surrey, England.

Christensen CM. 1965. Fungi in cereal grains and their products. pp. 9-14. In Mycotoxins in Foodstuffs, Wogan GN (ed.). MIT Press: Cambridge, MA.

Eshetu Bekele. 1985. A review of research on diseases of barley, tef and wheat in Ethiopia. pp. 79-108. In A Review of Crop Protection Research in Ethiopia, Abate T (ed.). IAR: Addis Ababa, Ethiopia.

Inglis DA, Cook RJ. 1981. *Calonectaria nivalis* causes scab in the Pacific Northwest. Plant Disease **65**:923-924.

Martin RA, Johnston HW. 1982. Effects and control of *Fusarium* diseases of cereal grains in the Atlantic Provinces. Canadian Journal of Plant Pathology **4**:210-216.

Mirocha CJ, Christensen CM. 1974. Fungus metabolites toxic to animals. Annual Review of Phytopathology **12**:303-330.

Nelson PE, Toussoun TA, Marasas WFO. 1983. *Fusarium* species: An Illustrated Manual for identification. The Pennsylvania State University: University Park, PA.

Stack RW, McMullen MP. 1985. Head blighting potential of *Fusarium* species associated with spring wheat heads. Canadian Journal of Plant Pathology **7**:79-82.

Stewart RB, Dagnatchew Yirgou. 1967. Index of Plant Diseaes in Ethiopia. Aricultural Experiment Station Bulletin No.30. College of Agriculture, HSIU: Addis Ababa, Ethiopia.

Sturz AV, Johnston HW.1983. Early colonization of the ears of wheat and barley by *Fusarium poae*. Canadian Journal of Plant Pathology **5**:107-110.

Vargo RH, Baumer JS. 1986. *Fusarium sporotrichioides* as a pathogen of spring wheat. Plant Disease **70**:629-631.

Wiese MV. 1987. Compendium of Wheat Diseases (2nd ed.). The American Phytopathological Society: St. Paul, MN. 16 pp.

Windels CE, Burnes PM, Kommedahl T. 1988. Five-year preservation of *Fusarium* species on silica gel and soil. Phytopathology **78**:107-109

Young JC, Fulcher RG. 1984. Mycotoxins in grains: causes, consequences and cures. Cereal Food World **29**:725-728.