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FUSARIUM SCAB OF SORGHUM IN NIGERIA

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Summary

Fusarium moniliforme was found to be associated with seedling blight, stalk rot, head blight and scabbed seed of sorghum grown in experimental plots during the wet season at Samaru, Nigeria. Grain of 2266 lines were examined for the presence of Fusarium spp. Ninety percent of the Fusarium isolates were F. moniliforme and 10% were F. roseum f. cerealis. Forty of the lines had 100% Fusarium infection and zero germination, and seed of all of these lines showed typical scabbed symptoms. Individual scabbed kernels were found in nearly all lines studied. Only 60 of the 2266 lines were free of Fusarium. There was increased incidence of Fusarium on the seed when the heads were covered at flowering with Kraft paper bags. Seed grown under irrigation and harvested during the dry season had a much lower incidence of scab than seed grown and harvested in the wet season. Seed produced during the dry season and treated with a seed dressing containing thiram had a low incidence of Fusarium when germinated.

INTRODUCTION

Fusarium spp. attack sorghum at all stages of growth (6, 9). Leukel and Martin (5) pointed out the seriousness of Gibberella fujikuroi (Saw.) Wr. = Fusarium moniliforme Sheldon as the cause of seed rot and seedling blight of sorghum in the United States. Tullis (10) described a stalk rot caused by this fungus in Texas. The scab or head blight disease caused by G. zeae (Schw.) Petch. = F. roseum f. cerealis (Cke.) Snyd. & Hans. has been studied on maize (corn), wheat, barley and rye (2, 3, 7, 8), but less attention has been given to seed damage caused by this disease on sorghum. G. zeae and G. fujikuroi were both isolated from sorghum, and a head blight caused by G. zeae has been found in Central Africa (6). Infection occurs during periods of high humidity at flowering and during the time the seed is maturing. The kernels become shrunken, lose luster, have a rough surface, and take on a scabby appearance. At harvest time the infected kernels weigh less than the normal ones. When the fungus invades the endosperm and embryo the seed will not germinate, and when such seed are placed under high humidity a heavy growth of mycelium and conidiospores develops on the surface.

METHODS AND MATERIALS

We made four studies:

1) We made a survey of disease caused by Fusarium spp. on sorghum plants growing in the field during the wet season and growing in sand culture during the dry season.
2) We made a study of the prevalence of Fusarium spp. and other fungi on 2266 lines of sorghum grown at Samaru during the wet season.
3) We compared Fusarium infection on seed produced under Kraft paper bags with those not bagged in 12 lines selected from the world collection.
4) We compared the Fusarium infection on seed grown during the wet and dry seasons on the same 12 lines of sorghum. The seed was harvested, dried, stored in the laboratory and treated with thiram at the manufacturer's recommended rate. The seed were germinated immediately after the application of thiram, and we compared the prevalence of Fusarium with the untreated seed. The seed that matured during the wet season remained in storage for 6 months and the dry season-produced seed remained in storage for 1 month before the tests were run. One hundred seed per line were studied.

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Identification of fungi reported in this paper was verified by the Commonwealth Mycological Institute, Kew, Surrey. The assistance of Dr. Margaret A. Keay and Dr. Mary Noble is gratefully acknowledged.

A blotter paper technique was used in all four studies. Blotter paper was sterilized in a 0.5% solution of sodium hypochlorite in water. Seed were wrapped in the sterilized blotter paper and placed in a moisture chamber. Fungi that developed on the surface of the seed were identified 10 days later. Fungi that could not be identified by this technique were plated on potato-dextrose agar and identified.

RESULTS

F. moniliforme was found more often than any other species of fungi in this study. It was found associated with seedling blight, stalk rot, deformed leaves, head blight and scabbed seed. It was the only species of fungi found on seedling-blighted sorghum plants growing in sand culture during the dry season, which indicated that primary inoculum of Fusarium was seedborne.

Seed harvested during the wet season was heavily infected with Fusarium spp. Ninety percent of the isolates were F. moniliforme and 10 percent were F. roseum f. cerealis. Fusarium heterosporum Nees ex Fr. and other Fusarium spp. were found in trace amounts. Seed infections were grouped into four classes (Table 1). Of the 2266 lines tested, only 40 had 100% infection and zero germination. All 40 lines would fall into class 3 (Table 1). Sixty lines were free of Fusarium and were placed in class 0. The other 2166 lines studied were not clear-cut in their reaction; therefore, Table 2 shows the range of infection observed. Table 2 does not take into consideration the germination of the seed. The classification in Table 1, however, includes germination. A large number of lines had varying percentages of scabbed seed (class 3) which would not germinate. Some lines with Fusarium present on the seed germinated and grew, and the fungus penetrated into the young seedlings. This characteristic was found in most of the West African sorghum lines with lax heads. Lines with compact heads had more scab than lines with lax head types.

Table 1. Classes of infection on sorghum seed caused by Fusarium spp.

Class	Description
0	No Fusarium found on the seed.
1	Fusarium found on the surface of the seed. The seed germinated and the fungus may or may not penetrate the plant parts.
2	Discolored specks appear on the surface of the seedcoat associated with small pinpoint infections inside the endosperm. Tufts of conidiospores of Fusarium spp. appear on the specks when the seed are placed under high humidity. Most of these seed will germinate and the fungus penetrates the coleoptile and roots of the young seedling.
3	Typical scabbed kernels. The fungus has invaded the endosperm and embryo. Seed are shrivelled, discolored and will not germinate. Heavy mycelial growth develops on the surface of the kernels under high humidity. Infected kernels weigh less than normal ones.

Table 2. Seed infection in sorghum lines infected with Fusarium spp. Seed harvested during the wet season at Samaru, Nigeria in 1965.

Number of lines infected	Range of infection by percent
60	0
481	1-25
537	26-50
470	51-75
393	76-99
325[a]	100

[a]Forty of these lines had zero germination.

Table 3. Effect of bagging sorghum heads on the infection of seed by Fusarium spp.

Indian selection number of sorghum	Percent of seed infected	
	bagged	not bagged
176	84	60
189	68	44
216	100	44
220	100	48
229	96	84
2806	96	44
3482	96	52
3528	88	24
7078	64	16
7093	76	44
8094	64	32
8237	80	52

Table 4. Effect of thiram on Fusarium spp. infection of seed harvested during the wet and dry seasons, Samaru, Nigeria, 1965-1966, as determined by the blotter paper technique after germination.

Indian selection number	Percent of seed infected with Fusarium			
	Wet season		Dry season	
	untreated	treated	untreated	treated
176	84	68	8	0
189	68	56	0	0
216	100	64	16	4
220	100	84	12	4
229	96	76	4	4
2806	96	76	16	4
3482	96	68	8	0
3528	88	48	4	0
7078	64	52	12	4
7093	76	40	0	0
8094	64	48	0	0
8237	80	32	12	0
Mean	84	60	8	1.5
Range	64-100	32-84	0-16	0-4

Other fungi found on sorghum seed were: Phoma insidiosa F. Tassi = Phyllosticta sorghina Saccardo, Helminthosporium halodes Drechsler, Ramulispora sorghi (Ell. & Ev.) L. S. Olive & Lefebvre, Gonatobotrys africanus Saccas, Aspergillus niger v. Tiegh., Colletotrichum graminicolum (Ces.) G. W. Wils., Alternaria sp. and Penicillium sp. Other fungi that did not sporulate were present. A. niger was the predominant fungus found on seed harvested during the dry season. A stalk rot incited by A. niger was observed on some lines during the dry season.

Fusarium infection was higher on heads bagged with Kraft paper bags than open-pollinated heads (Table 3).

Seed harvested during the dry season had less Fusarium infection than did seed harvested in the wet season; and in both seasons treating the seed with thiram reduced the incidence of Fusarium (Table 4). Seed harvested during the dry season had a very low incidence of all fungi. Treating the seed harvested during the wet season reduced the incidence of all fungi but did not give complete control. Treating seed with thiram did not give control of Aspergillus niger.

DISCUSSION

Environmental factors influence the damage on sorghum caused by Fusarium spp. Head blight and scab develop rapidly during heavy rains and high humidity. This has been reported

by other workers (3, 5, 6). Any environmental condition that is unfavorable for optimum growth of the sorghum plant favors a quick invasion by the pathogen and production of a disease. Slight variations in optimum growing conditions for the sorghum plants in the early stages of growth favor rapid development of Fusarium spp. and seedling disease develops. If the host and disease develop together, the fungus may grow slowly at the growing point of the plant and produce gibberellic acid. The presence of this growth substance probably caused the twisted enlongated leaves and stems observed in this study. Tullis (10) showed that sorghum plants growing under dry conditions developed stalk rot. The current study indicates that F. moniliforme was probably present in the sorghum plants, and when the dry weather occurred the growth of the sorghum plant slowed down or ceased and the stalk rot disease occurred.

One of the best methods of controlling diseases of Fusarium spp. is by the use of disease-free seed. Results demonstrate that good control of seedborne infection can be obtained by harvesting seed in the dry season and treating it with thiram. Crop rotation and plowing under infected stalks have been recommended for the control of the disease in other crops (3). Resistant or tolerant varieties have been selected in wheat, barley and maize (3, 8). Christensen (1) and Shands (8) have shown that a number of factors other than blighted kernels must be taken into consideration in a selection program for scab resistance. Many barley varieties have Fusarium present, but the seed do not become scabbed. The compactness of heads affects the incidence of scab in other crops (1, 2, 8). Many of the West African sorghum varieties have lax heads and Fusarium spp. were found on the heads but no scab developed. By contrast, the compact heads of the Durra class of sorghums were heavily scabbed. The time the seed matures is very important in relation to scab development at Samaru. Most of the sorghums introduced from the United States scabbed because they matured during the rainy season. No scab developed on West African sorghum varieties that matured after the rains ceased and when the humidity was very low.

The high incidence of Fusarium spp. on sorghum may come from inoculum other than that carried on the seed. The fungus can live from one season to the next as a saprophyte on stalks and straw. These materials are used in the construction of houses, fences and grain stores in most of the sorghum-growing areas of Africa, and are therefore commonly available as dry-season hosts.

Emetic toxins are known to be produced in barley infected with F. roseum f. cerealis (3, 7). These toxins only affect animals with a single stomach. The grain can be fed to poultry and mature cattle without harm (3). Sorghum seed infected with F. moniliforme has never been analyzed for the presence of emetic substances or other toxins. In view of the high incidence of this fungus on seed grown during the wet season, such a study should be made because sorghum is used for human and animal feed in many parts of the world. If the emetic toxin is present, the grain could be diverted to poultry feed, and could be fed to cattle after the rumen digestive system has developed. Although a large number of other fungi including A. niger were found in sorghum seed, A. flavus was not found during this study.

Hsi (4) recently reported a stalk rot caused by A. niger on sorghum growing under irrigation in the southwestern United States. The disease was observed on sorghum growing under irrigation at Samaru during the dry season. A. niger was the predominant fungus found on seed produced during the dry season, and it was not controlled by treating the seed with thiram.

Literature Cited

1. CHRISTENSEN, J. J. 1963. Variability in microflora in barley kernels. Plant Disease Reptr. 47: 635-638.
2. DICKSON, J. G. 1923. Influence of soil temperature and moisture on the development of seedling blight of wheat and corn caused by Gibberella saubinetii. J. Agr. Research 23: 837-870.
3. DICKSON, J. G. 1956. Diseases of Field Crops. McGraw-Hill Book Co., Inc., New York. 517 pp.
4. HSI, DAVID C. H. 1966. A new sorghum stalk rot caused by Aspergillus niger. Plant Disease Reptr. 50: 352-353.
5. LEUKEL, R. W., and J. H. MARTIN. 1943. Seed rot and seedling blight of sorghum. U.S. Dept. of Agr. Tech. Bull. 839.
6. SACCAS, A. M. 1954. Les champignons parasites des sorghos (Sorghum vulgare) et des penicillaires (Pennisetum typhoideum) in Afrique Equatoriale Francaise. Agron. trop. Nogent 9: 135-173, 263-301, 647-686.

7. SHANDS, R. G. 1937. Longevity of Gibberella saubinetii and other fungi in barley kernels and its relation to the emetic effect. Phytopathology 27: 749-762.
8. SHANDS, R. G. 1939. Chevron, a barley variety resistant to stem rust and other diseases. Phytopathology 29: 209-211.
9. TARR, S. A. J. 1962. Diseases of Sorghum, Sudan Grass and Broom Corn. Commonwealth Mycol. Inst., Kew, Surrey. 388 pp.
10. TULLIS, EDGAR C. 1951. Fusarium moniliforme, the cause of a stalk rot of sorghum in Texas. Phytopathology 41: 529-535.

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X IN VITRO INCREASE IN VIRUS INFECTIVITY II

C. E. Yarwood[1]

Abstract

When young leaves of sugarbeet systemically infected with cucumber mosaic virus were ground with K_2SO_3 and water, diluted to 0.5% leaf tissue and 0.1% K_2SO_3, used as inoculum immediately and after time intervals, the infectivity of this inoculum increased by an average of 6-fold in 20 minutes and as much as 132-fold in one test. The addition of caffeine, sucrose, magnesium silicate, and adenosine triphosphate (ATP) usually increased both the initial infectivity and the *in vitro* increase in infectivity of K_2SO_3-virus mixtures. The infectivity of such preparations usually began to decrease within 3 hours of preparation but the presence of ATP delayed this decrease. No claim of increase in virus is made.

INTRODUCTION

Although *in vitro* increase in virus infectivity and of virus has been reported or suggested several times (1, 2, 5, 7, and others could be cited) neither is adequately confirmed (9). The increased infectivity on standing, of suspensions of cucumber mosaic virus (CMV) from old beet leaves (12) was considered as primarily due to magnesium silicate ($Mg_2Si_3O_8 \cdot 5H_2O$, here abbreviated MgSi), though K_2SO_3 was considered essential for the increase, and K_2HPO_4 was considered desirable to bring numbers of lesions to significant levels. This concept is now shown to be wrong, and even greater increases in infectivity have resulted from aging suspensions of young beet leaves with K_2SO_3 as the only additive. Caffeine, ATP and sucrose added to virus: K_2SO_3 suspensions resulted in greater *in vitro* increases in infectivity than K_2HPO_4 or MgSi, though these latter chemicals increased the initial infectivity.

METHODS

About 0.05 g of leaf inoculum was ground in 1 ml of water plus the test chemicals at about 26°C, diluted to 10 ml with water, and applied to assay leaves at intervals. The interval from grinding and dilution of donor tissue till applying the resulting inoculum is called the age of the inoculum, and inoculum which has been allowed to stand is called aged inoculum. The shortest period from the start of grinding till completion of inoculation of the first leaf was about 50 seconds. Such inoculum is called fresh inoculum or control inoculum. Inoculum was applied to the upper surfaces of primary cowpea leaves (*Vigna sinensis* cv. Blackeye) at 9 to 13 days after seeding in a peat:sand:fertilizer mixture at about 22°.

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