Sorghum diseases prevalent in Ghana

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ABSTRACT

Field survey, screening trials and laboratory investigation were used to determine the prevalence of sorghum diseases in the major sorghum-growing climatic zones (Sudan, northern and southern Guinea savanna). Farmers' fields were surveyed in 1997. Ten sorghum entries were evaluated under natural field conditions in 1997 and 1998 at Damongo for their reaction to foliar and panicle diseases while seed samples of field-harvested sorghum were assessed for fungal infection using the blotter method. Two main types of sorghum, *viz*. the early-maturing, brown-seeded, guinea or guinea-caudatum type and the late-maturing, photoperiod-sensitive, white-seeded, guinea or guinea-caudatum type were found in the sorghum-growing areas. The survey showed that sorghum was cultivated under a range of cropping systems in all possible crop mixtures. Grey leaf spot (*Cercospora sorghi*), oval leaf spot (*Ramulispora sorghicola*), zonate leaf spot (*Gloeocercospora sorghi*) and covered smut (*Sporisorium sorghi*) were prevalent in all the sorghum-growing areas. Other diseases recorded were leaf blight (*Exserohilum turcicum*), sooty stripe (*Ramulispora sorghi*), grain mould (caused by a complex group of fungi), long smut (*Sporisorium ehrenbergii*), head smut (*Sporisorium reiliana*), rust (*Puccinia purpurea*) and rough leaf spot (*Ascochyta sorghi*). Anthracnose (*Colletotrichum graminicola*) occurred infrequently across the regions. *Striga hermonthica* was more prevalent in the two Upper regions than in the Northern Region. The sorghum entries varied considerably in their susceptibility to the field diseases, with severity mean scores ranging from 2.5 to 3.6. Eight species of fungi were recorded from seed samples. The occurrence of these varied with the sorghum entries, with the genera *Fusarium* and *Phoma* dominating, followed by *Curvularia*.

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RÉSUMÉ

NUTSUGAH, S. K., ATOKPLE, I. D. K. & LETH, V. : *Les maladies de sorgho en prévalence au Ghana*. Enquête sur le terrain, essais de dépistage et investigation de laboratoire étaient faites pour déterminer la prévalence de maladies de sorgho dans les zones climatiques principales (soudano-savane et savane guinéenne du nord et du sud) cultivant le sorgho. L'enquête était menée en 1997 aux champs d'agriculteurs. Dix variétés cultivées de sorgho étaient évaluées sous les conditions naturelles au champ en 1997 et 1998 à Damongo pour leur réactions aux maladies foliaires et aux maladies de panicules alors que les échantillons de graine de sorgho moissonnée de champ étaient évalués pour infection fongique en employant la méthode de buvard. Deux types principaux de sorgho à savoir la maturation tôt: graine-brune, guinée ou le type caudatum guinéen et la maturation tardive: sensible à la photopériode, graine-blanche, guinée ou le type caudatum guinéen étaient rencontrés dans les zones cultivant le sorgho. L'enquête révélait que le sorgho est cultivé sous les systèmes de culture divers dans toutes les associations des cultures possibles. La tache à feuille grise *(Cercospora sorghi)*, la tache à feuille ovale *(Ramulispora sorghicola)*, la tache à feuille zonée *(Gloeocercospora sorghi)* et le couvert de charbon des céréales *(Sporisorium sorghi)* étaient en prévalence dans toutes les zones cultivant le sorgho. D'autres maladies observées étaient la rouille des feuilles *(Exserohilum turcicum)* la rayure de suie *(Ramulispora sorghi)* la moisissure de grain (causée par un groupe complexe de fongus), le charbon long des céréales *(Sporisorium ehrenbergii)*, le charbon de tête *(Sporisorium reiliana)*, la rouille *(Puccinia purpurea)* et la tache à feuille rugueuse *(Ascochyta sorghi)*. Anthracnose *(Colletotrichum graminicola)* se produit peu souvent à travers les régions. *Striga hermonthica* était la plus en prévalence dans les deux Hautes régions que dans la Région du Nord. Les variétés cultivées de sorgho variaient considérablement en leur prédisposition aux maladies du champ avec les résultats moyens de sévérité variant entre 2.5 et 3.6. Huit espèces de fongus étaient observées d'ehantillons de graine. L'apparition de ceux-ci variait avec les genres *Fusarium* et *Phoma* dominant, suivi par *Curvularia.*

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important food crop in Ghana. It is cultivated mainly as a subsistence rainfed crop in the Sudan, northern and southern Guinea savanna zones of the country, covering an area of 300,500 ha comprising Upper East, Upper West and Northern regions (MOFA, 2001). The three regions cover 41 per cent of the total land area of the country. The crop is grown primarily as a grain crop for human consumption and in brewing local beer (pito) (Langyintuo, Atokple & Manful, 1998). During the 2003 cropping season, 337,670 mt of sorghum was produced in Ghana from a land area of 340,530 ha (SRID, 2004).

The average grain yield of sorghum on-farm is generally low, ranging from 0.8 to 1.2 mt ha^{-1}. The yield-reducing factors include poor soil fertility, drought, *Striga hermonthica*, insect pests and diseases (Atokple *et al*., 1996). Of these, insect pests and diseases constitute important production constraints under traditional and improved farming systems. Midge infestations of 20 and 80 per cent have been reported in early and late-maturing varieties, respectively (Neve & Bowden, 1953). Neve & Bowden (1953) also reported that 'Nunaba' varieties with long papery glumes seemed resistant to midge. In 1964, stem borer infestation was estimated at 1-6 per cent (Smith, 1964). Smut infection was estimated in 1957 at 0-60 per cent, with 10 per cent as an average (Leather, 1958). Though *Cercospora* spp., *Gloeocercospora* spp., *Colletotrichum* spp. and *Striga* spp. are known to attack sorghum, reports are lacking in the extent of the losses they cause (Mercer-Quarshie, 1969).

A similar survey of farmers' fields in Nigeria during the 1990 cropping season in the major sorghum-growing climatic zones showed that foliar diseases anthracnose, oval leaf spot, grey leaf spot and sooty stripe were widely distributed (Pande *et al*., 1993). The incidence of other foliar diseases zonate leaf spot, rough leaf spot, leaf blight and sorghum downy mildew was low (Pande *et al*., 1993). Panicle diseases such as long, head, covered and loose smuts were common. The results of the survey, based on enzyme-linked immunosorbent assay, indicated for the first time in Nigeria that three viral diseases of sorghum were present (Pande *et al*., 1993).

The sorghum diseases prevalent in Ghana have not been adequately documented in any of the reviews on sorghum diseases. This paper reports results of a survey used in farmers' fields to determine the prevalence of sorghum diseases in Ghana. It also reports results of varietal screening to identify sources of resistance to foliar and panicle diseases for subsequent use in breeding programmes. The mycoflora of sorghum seeds were also studied.

Materials and methods

Disease surveys

The survey was used between 20 and 24 October 1997 during the flowering and hard dough growth stages of the sorghum crop in the major sorghum-growing areas (Sudan, northern and southern Guinea savanna) in northern Ghana. General observations were recorded on the types of sorghum and their distribution in the study area, the cropping systems under which sorghum is cultivated, as well as on the infestations by *Striga hermonthica*. Disease observations were recorded in 52 farmers' fields. In each field, 15 plants were assessed for fungal diseases of the foliage and panicle. Identities of the diseases were confirmed using standard references (ICRISAT, 1978; Frederiksen & Odvody, 2000). The blotter method (ISTA, 1966) was used to determine the fungal complex associated with mouldy kernels.

Ten seed samples of field-harvested sorghum in 1997 from Damongo were saved in plastic bags and stored in the cold room at 5 ºC for mycoflora study in 1998. The samples were taken to the Danish Institute of Seed Pathology, Copenhagen, Denmark, and examined for fungi by the blotter method (ISTA, 1966).

Seeds of each sample (200) were placed on three layers of moistened blotters in sterilised plastic Petri dishes (9-cm diameter) at the rate of 25 seeds

per dish and incubated at 21ºC under alternating cycles of 12 h near ultraviolet (NUV) and 12 h darkness for 7 days. Fungi developing from seeds were identified using standard references (Mathur & Kongsdal, 1998). Frequencies of observation were recorded and expressed as percentages of infected seeds in a sample.

Field screening

The trial was conducted for 2 years during the cropping seasons (July-October) of 1997-1998 at Damongo in the southern Guinea savanna zone. Ten sorghum entries were screened for foliar and panicle diseases. Individual plots consisted of two rows of 5 m each, with an inter-row spacing of 0.75 m. The trial was laid out in a randomised complete block design with four replications, and conducted under natural conditions of infection. Severity of foliar diseases was determined for 15 plants in each plot during crop growth, with the levels recorded at least once every 4 weeks. A rating scale of 1-9 (Frederiksen *et al.*, 1986), where 1 = no visible symptoms, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-30%, 6 = 31-40%, 7 = 41-50%, 8 = 51-75%, and 9 = over 75% of leaf area covered with lesions, was used to evaluate the sorghum entries for their reaction to foliar diseases.

Grain mould and smut were assessed on five randomly selected panicles 2 weeks after physiological maturity (black layer formation). The threshed grain mould rating scale of 1-9 (Bandyopadhyay & Mughogho, 1988), based on the grain surface area colonized by fungi was used; where 1 = no visible symptoms, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-30%, 6 = 31-40%, 7 = 41-50%, 8 = 51-75%, and 9 = over 75% of grain surface moulded. The smut severity scale of 1-9 (Thakur & King, 1988), where 1 = no visible symptoms, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-35%, 6 = 36-50%, 7 = 51-75%, 8 = 76-90%, and 9 = over 90% of grains replaced by smut sori, was used to score percentage of smut-infected florets in a panicle. Analysis of variance (ANOVA) (Gomez & Gomez, 1988) was performed on the mean disease severity ratings, and the means compared with the LSD test.

Results and discussion

Two main types of sorghum *viz*. the early-maturing, brown-seeded, guinea or guinea-caudatum type and the late-maturing, photoperiod-sensitive, white-seeded, guinea or guinea-caudatum type were found in the major sorghum-growing zones. The rainfall pattern determined the distribution of sorghum types; relatively early-maturing sorghums were found in the Upper East and Upper West regions, whereas late-maturing types were found in the Northern Region. Mean annual rainfall in sorghum-producing areas ranges from 1,000 to 1,400 in the Northern and 950 to 1,150 mm in the Upper regions (Froelich, Buah & Tanzubil, 1993).

The rainfall in northern Ghana is monomodal and lasts from April to September, but may extend to October in the Northern Region in the Guinean savanna zone. This explains why the late-maturing sorghums were found in the Northern Region. The Upper regions lie in the Sudano-savanna zone and have the lowest rainfall and a very short season; therefore, they have relatively short-duration sorghum types. Sorghum was rarely sole-cropped and it was often intercropped with maize, cowpea, pearl millet, and groundnut. Early-maturing sorghums had matured while late-maturing sorghums were setting seeds during the survey period.

Fifty-two fields were surveyed in the three regions for diseases. Grey leaf spot (*Cercospora sorghi*), oval leaf spot (*Ramulispora sorghicola*), zonate leaf spot (*Gloeocercospora sorghi*) and covered smut (*Sporisorium sorghi*) were prevalent in all the regions. Other diseases recorded were leaf blight (*Exserohilum turcicum*), sooty stripe (*Ramulispora sorghi*), grain mould (caused by a complex group of fungi), long smut (*Sporisorium ehrenbergii*), head smut (*Sporisorium reiliana*), rust (*Puccinia purpurea*) and rough leaf spot (*Ascochyta sorghina*) (Table 1). Anthracnose (*Colletotrichum graminicola*) was found infrequently in most fields across the

regions, suggesting that most landraces were resistant to the disease. *Striga hermonthica* was more prevalent in the Upper East and Upper West regions, which had drier and less fertile soils than in the Northern Region (Bandyopadhyay *et al*., 1997).

The introduction of new high-yielding varieties and increased sorghum production resulted in several leaf diseases becoming important. Grey leaf spot is the most common disease in the farmers' fields. Grain moulds are recognized as serious problems on early-maturing, compact-headed sorghum varieties under humid and rainy conditions in the southern Guinea savanna zone. Grain moulds reduce yield and the harvested grains are unacceptable for planting and consumption. Grain mould and weathering effects are major problems, with introduced genotypes maturing during conditions of high humidity in which harvested grain yields are often reduced (Thomas, 1992).

Three decades ago, foliar diseases were considered of little economic importance in northern Ghana (Mercer-Quarshie, 1969). This may have been due to resistance in sorghum landraces grown by farmers. Low fertility and intercropping, characteristic of most sorghum production systems in Ghana (Bandyopadhyay *et al*., 1997), may have provided additional deterrent to the development of epidemics of foliar diseases. However, with the changing crop husbandry practices (monocropping) and introduction of new high-yielding varieties (Kapaala, Framida, Naga White and Kadaga) for increasing and stabilising crop production, several foliar and seed-borne diseases became important (Nutsugah, Ayensu & Tsigbey, 1999; Nutsugah *et al*., 2002; Nutsugah *et al*., 2002; Nutsugah *et al*., 2004). During this survey, Kapaala was found to be extensively cultivated in the Sudan, northern Guinea and parts of the southern Guinea savanna zones of Ghana. This variety was found to be infected by long smut, sooty stripe, and grain mould. Although long-duration varieties were found with symptoms of grey leaf spot, zonate leaf spot and leaf blight, these diseases heavily attacked the short-duration varieties.

TABLE 1

Fungal Diseases of Sorghum Found in Northern Ghana

Disease	*Causal organism*
Grain moulds	*Acremonium, Bipolaris, Cercospora Exserohilum, Fusarium, Gloeocercospora Nigrospora, Phoma, Phomopsis* and *Verticillium*
Foliar diseases	
Grey leaf spot	*Cercospora sorghi*
Oval leaf spot	*Ramulispora sorghicola*
Zonate leaf spot	*Gloeocercospora sorghi*
Leaf blight	*Exserohilum turcicum*
Sooty stripe	*Ramulispora sorghi*
Rust	*Puccinia purpurea*
Rough leaf spot	*Ascochyta sorghi*
Anthracnose	*Colletotrichum graminicola*
Smuts	
Covered smut	*Sporisorium sorghi*
Long smut	*Sporisorium ehrenbergii*
Head smut	*Sporisorium reiliana*

The occurrence of sorghum diseases from natural infection varied considerably among the entries screened (Table 2). Grain mould seemed to be the most frequently occurring disease with a severity mean score of 3.6, followed by zonate leaf spot with a severity mean score of 3.5. The other field diseases recorded were leaf blight, grey leaf spot and long smut with severity mean scores of 3.1, 2.9 and 2.5, respectively (Table 2). Significant differences were detected among sorghum entries for their susceptibility to the field diseases. Six entries (Kadaga, Framida, Naga White, S 219, ICSV 16-5 and 90 W 197) had high severity scores of 5.0 or 6.0 to one or two diseases. Among the 10 entries, Framida was the most susceptible, followed by Naga White, 90 W 197, S 219, ICSV 16-5, NSV 1

TABLE 2

Field Reaction of Sorghum Grown at Damongo to Foliar and Panicle Diseases During 1997-1998 Cropping Seasons

Entry	*Grey leaf spot*[1]	*Zonate leaf spot*[1]	*Leaf blight*[1]	*Grain mould*[2]	*Long smut*[3]
Kadaga	2.0	6.0	2.0	2.0	2.0
Framida	3.0	4.0	4.0	6.0	3.0
Naga White	3.0	4.0	4.0	6.0	2.0
Kapaala	2.0	2.0	3.0	3.0	2.0
NSV 1	3.0	3.0	3.0	2.0	3.0
NSV 2	2.0	3.0	1.0	3.0	1.0
S 219	6.0	6.0	1.0	4.0	1.0
ICSV 210	3.0	1.0	4.0	3.0	2.0
ICSV 16-5	1.0	5.0	4.0	4.0	3.0
90 W 197	4.0	1.0	5.0	3.0	6.0
Mean[4] (10 entries)	2.9	3.5	3.1	3.6	2.5
LSD (5%)	0.9	0.6	0.6	0.5	1.0
CV (%)	20.6	13.4	13.8	10.7	26.7

[1]A rating scale of 1-9 (Frederiksen *et al*., 1986), where 1 = no visible symptoms, 2 = 1-5 per cent, 3 = 6-10 per cent, 4 = 11-20 per cent, 5 = 21-30 per cent, 6 = 31-40 per cent, 7 = 41-50 per cent, 8 = 51-75 per cent, and 9 = over 75 per cent of leaf area covered with lesions.
[2]Grain mould rating scale of 1-9 (Bandyopadhyay & Mughogho, 1988) based on the grain surface area colonized by fungi, where 1 = no visible symptoms, 2 = 1-5 per cent, 3 = 6-10 per cent, 4 = 11-20 per cent, 5 = 21-30 per cent, 6 = 31-40 per cent, 7 = 41-50 per cent, 8 = 51-75 per cent, and 9 = over 75 per cent of grain surface moulded.
[3]Smut severity rating scale of 1-9 (Thakur & King, 1988), where 1 = no visible symptoms, 2 = 1-5 per cent, 3 = 6-10 per cent, 4 = 11-20 per cent, 5 = 21-35 per cent, 6 = 36-50 per cent, 7 = 51- 75 per cent, 8 = 76-90 per cent, and 9 = over 90 per cent of grains replaced by smut sori.
[4]Mean of four replications.

and Kadaga. The ICSV 210 and Kapaala entries were rated as moderately susceptible because they recorded low disease incidence. The NSV 2 entry showed resistant reaction to all field diseases studied, showing great potential for use in a host-plant resistance strategy to combat foliar and panicle diseases.

Naga White and Kapaala had been previously evaluated in a regional sorghum head-bug and grain mould resistance variety trial in 1996 and 1997 (SARI, 1996). Grain mould rating at Nyankpala for Naga White was 6.0, and 6.5 for Kapaala in 1996. In 1997, the rating was 6.3 for Naga White and 7.0 for Kapaala (Ratnadass *et al*., 2003). A rating of 6.0 was recorded for Naga White at Damongo in this study; thus, corroborating the earlier results of its susceptibility to grain mould. Further work on foliar and panicle diseases will be directed at identifying entries with stable resistance to these diseases and estimating yield losses from the diseases.

Table 3 lists the percent mean infection of fungi recorded in seed samples of sorghum harvested in 1997 at Damongo and tested by the blotter method. Eight fungal species were recorded from field-harvested sorghum seeds of which *Fusarium* sp. (23.3-89.5%) and *Phoma sorghina* (6.8-37.8%) predominated and were found in all the seed samples tested. *Gloeocercospora sorghi* (0.3-3.3%), *Bipolaris* sp. (1.0-6.5%) and *Curvularia lunata* (0.8-10.3%) were found in nine, eight and seven of the entries tested, respectively. The least occurring fungi, *Cercospora sorghi* (0.3%) and *Colletotrichum* sp. (0.3%), were each

TABLE 3

Percent Mean Infection of Fungi Recorded in Seed Samples of Sorghum Harvested in 1997 at Damongo and Tested by the Blotter Method

	Entry									
Fungus	*Kadaga*	*Framida*	*Naga White*	*Kapaala*	*NSV 1*	*NSV 2*	*S 219*	*ICSV 210*	*ICSV 16-5*	*90 W 197*
Bipolaris sp.	2.8		2.5	6.5	1.3	1.5	1.0	1.5		2.8
Exserohilum rostratum			0.3	0.5		1.3		0.3	0.5	
Fusarium sp.	74.0	89.5	37.5	85.0	28.0	23.3	65.8	36.8	59.5	72.5
Gloeocercospora sorghi	3.0	0.5	1.0	0.5	0.3	0.3	3.3	0.5	1.3	
Phoma sorghina	23.8	24.5	6.8	29.8	29.0	25.5	37.8	24.5	24.3	35.5
Curvularia lunata	2.5	3.8		8.0		0.8	1.8		0.8	10.3
Colletotrichum sp.				0.3						
Cercospora sorghi					0.3					

recorded in one entry but with different genetic background; while *Exserohilum rostratum* (0.3-1.3%) was found in five entries (Table 3).

Predominance of a *Fusarium* sp. points to its potential for seed transmission. This is because *F. moniliforme* (syn. *F. verticillioides*) is one of the most important seed-borne fungi recorded in sorghum, and has been reported to cause seedling blight, root and stalk rot, grain mould and head blight (Tullis, 1951; Zummo, 1980; Nutsugah *et al*., 2004). *Fusarium moniliforme*, *P. sorghina* and *C. lunata* are very important when grain maturity coincides with late rains and can cause serious infection, leading to considerable reduction in yield. More significantly, grain quality is adversely affected. The physical effects of moulds on grain may include discoloured pericarp, softened and chalky endosperm, decreased grain size and density, sprouting, presence of mycotoxins, and altered composition of phenolic compounds (Williams & Rao, 1981).

Conclusion

The results from the field survey, screening trials and the seed mycoflora study indicated the prevalence of fungal diseases on sorghum in Ghana. Grey leaf spot, oval leaf spot, zonate leaf spot, and covered smut were prevalent in all the regions. Other fungal diseases observed were leaf blight, sooty stripe, grain mould, long smut, head smut, rust, rough leaf spot, and anthracnose.

Five fungal diseases (grey leaf spot, zonate leaf spot, leaf blight, grain mould and long smut) were recorded on the sorghum entries screened in the field. None of the entries evaluated was free of all diseases, although various degrees of susceptibility were observed. The NSV 2 entry showed resistance to all diseases. Framida was most susceptible, followed by Naga White, 90 W 197, S 219, ICSV 16-5, NSV 1 and Kadaga. The ICSV 210 and Kapaala entries were moderately susceptible.

Eight fungal species were associated with the seeds. Marked differences were observed in the level of infection by the various fungi. A *Fusarium* sp. and *Phoma sorghina* were among the most frequently recorded fungi. Other fungi, *Curvularia lunata*, *Bipolaris* sp., *Gloeocercospora sorghi* and *Exserohilum rostratum* were also present in considerable frequencies. The infrequently recorded fungi were *Colletotrichum* sp. and *Cercospora sorghi*.

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