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Prevalence of sorghum diseases in Nigeria†

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Abstract. A survey was conducted in farmers' fields in Nigeria during the 1990 cropping season to determine the prevalence of sorghum diseases in the four major sorghum-growing climatic zones (Sahel, Sudan, northern Guinea, and southern Guinea). The foliar diseases anthracnose (*Colletotrichum graminicola*), oval leaf spot (*Ramulispora sorghicola*), sooty stripe (*Ramulispora sorghi*) and grey leaf spot (*Cercospora sorghi*) were widely distributed. Anthracnose was predominant throughout the areas surveyed with ≥40% leaf area covered or destroyed by lesions in 70% of the surveyed fields. The incidence of other foliar diseases was low. Among the panicle diseases, long smut (*Tolyposporium ehrenbergii*) incidence was ≤10% in ≥20% farmers' fields in the sahelian zone. Head (*Sporisorium reilianum*), covered (*Sporisorium sorghi*) and loose (*Sphacelotheca cruenta*) smuts were common, but their incidence varied from 1 to 10% in the Sahel, Sudan, northern Guinea and southern Guinea zones. Survey results based on ELISA indicated for the first time in Nigeria the presence of three virus diseases of sorghum: maize mosaic (maize mosaic virus), maize stripe (maize stripe virus), and a potyvirus in the Sudan, northern Guinea, and southern Guinea zones. Grain moulds, charcoal rot (*Macrophomina phaseolina*), and bacterial diseases were not observed during this survey.

1. Introduction

Sorghum (*Sorghum bicolor* (L.) Moench), locally called 'guinea-corn' is an important cereal crop in Nigeria. It is cultivated mainly as a subsistence rainfed crop in the Sahel, Sudan, northern Guinea and southern Guinea zones of the country, covering an area of about 4·6 million ha (9·7% of the world sorghum area) between latitudes 6°30′ and 14°N (Dogget, 1988). Currently ≥95% of sorghum grain produced in the four climatic zones is consumed in the form of '*tuwo*' (thick porridge), '*ogi*' or '*kamu*' (thin gruel), and stalks are used for building, fencing, and fodder (Obilana *et al.*, 1984).

Sorghum landrace cultivars with different maturities, panicle types, grain colour and grain quality are well adapted to local conditions, and are still grown over large areas. The most common landraces of sorghum in Nigeria are Kaura, Fara-Fara, Guinea and Chad (Prasada Rao *et al.*, 1985). Mean annual rainfall in sorghum-producing areas of the country varies from 1270 mm in the southern parts to 510 mm at the fringes of the Sahel (Yayock *et al.*, 1987). Sorghum is cultivated under a range of cropping systems in all possible crop mixtures, and about 178 crop mixtures have been documented in the four climatic zones (Norman *et al.*, 1982). Depending upon the rainfall, soil type and cropping system the average yields of sorghum vary from 540 to 1200 kg/ha. The current annual production of sorghum is estimated to be about 4·5 million tonnes (Dogget, 1988).

Diseases constitute an important production constraint under both traditional and improved farming systems. The yield loss in sorghum grain due to diseases (excluding *Striga*) was estimated to be 10–12% (Selvaraj, 1980). Although more than 20 fungal diseases of sorghum have been reported from Nigeria (Tyagi, 1980), their distribution and prevalence have not been reported from farmers' fields of different sorghum-growing regions of Nigeria. While diseases due to bacteria and viruses are not well documented, the importance of bacterial diseases was emphasized by Sundaram (1980) and Zummo (1975).

In this paper we report the results of a systematic survey conducted in farmers' fields to determine the relative incidence and severity of sorghum diseases in the Sahel, Sudan, northern Guinea and southern Guinea climatic zones of Nigeria.

2. Materials and methods

The survey was conducted between 16 September and 22 October 1990 during the flowering and hard dough growth stages of the sorghum crop (Vanderlip and Reeves, 1972) in the major sorghum-growing areas in four climatic zones (Figure 1). Disease observations were recorded in 272 farmers' fields (25, 81, 127 and 39 in the Sahel, Sudan, northern Guinea, and southern Guinea zones, respectively). In general stops were made at intervals of 10–70 km distance on a survey route of 5550 km, and one to seven fields were scouted at each location. Stops were less frequent in areas where sorghum was sparsely grown.

The incidences of downy mildew and smuts were scored on a visual rating scale of 1–5, where, 1 = no infected

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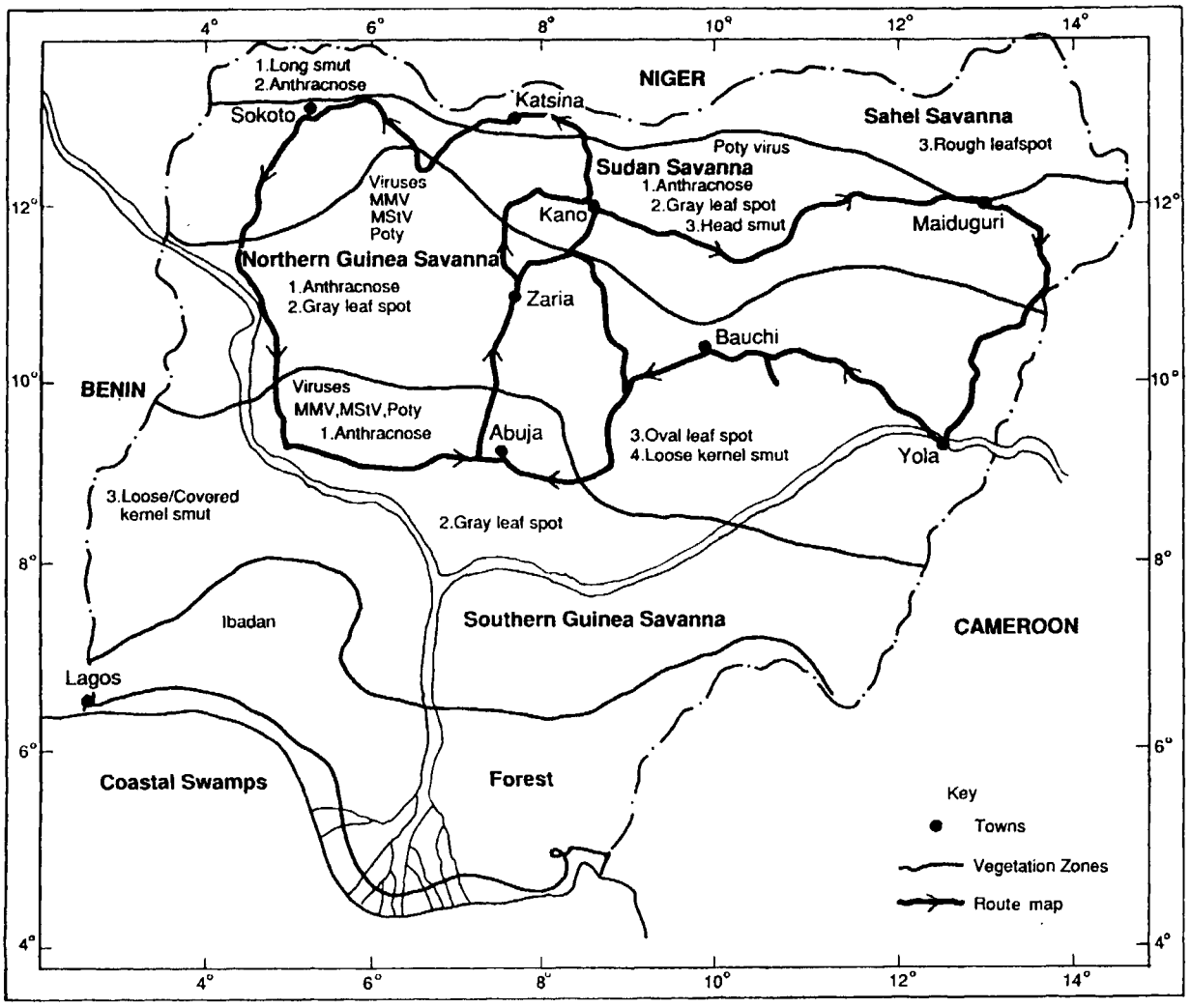

Figure 1. Survey route and occurrence of dominant sorghum diseases in four climatic zones of Nigeria, crop season 1990.

plants, 2 = <1%; 3 = 1–5%; 4 = 6–10% and 5 = > 10% plants infected. In each field the incidences of downy mildew, smuts, foliar fungal diseases, and diseases caused by virus were recorded for 360 plants. Each field was divided into four quadrants and in each quadrant 90 plants were assessed in 10 random rows. These rows represented the transects across different parts of the quadrant. The incidence of a disease in each field at a location was used to calculate the location average, and the incidence at each location was used to calculate the incidence of a disease in a climatic zone. Percentages of the total fields in incidence classes were used to show the distribution of downy mildew and smuts in a climatic zone. Since every plant in the fields had leaf disease(s) symptoms, leaf disease(s) severity in each field was scored using a visual rating scale of 1–5, where 1 = no visible symptoms; 2 = 1–5%; 3 = 6–20%; 4 = 21–40%; and 5 = >40% leaf area covered with lesions. Leaf disease(s) severity in each field was further used to calculate location and zone averages. The percentage of the total number of fields in each severity class at a location was used to determine the distribution of each leaf disease in a climatic zone.

Virus disease incidence in each zone was calculated based on the enzyme-linked immunosorbent assay (ELISA) test (Hobbs *et al.*, 1987; Sudarshana and Reddy, 1989). The incidence of virus diseases was very low (<1%) in all the surveyed fields. Plants showing virus disease-like symptoms were taken for sampling along with two apparently healthy-looking plants as controls from each field. The leaves were cut into bits, pooled, and 2 g were taken for sampling. Plant extract dilutions of 1 : 100 and 1 : 1000 prepared in carbonate buffer, pH 9·6 were applied (200 µl) to the wells of the microtitre plate in triplicate for each antiserum. The plates were left overnight (10–12 h) in a refrigerator, next day washed three times with PBS-T (phosphate-buffered saline containing 0·5% Tween 20), wrapped in wet paper towels and placed within polyethylene bags. All plates were stored in an ice-box till assayed. The time lapse from coating to assay was 1 week. The antisera used were maize mosaic, maize stripe and a potyvirus. The antiserum dilution was 1 : 10000, cross-

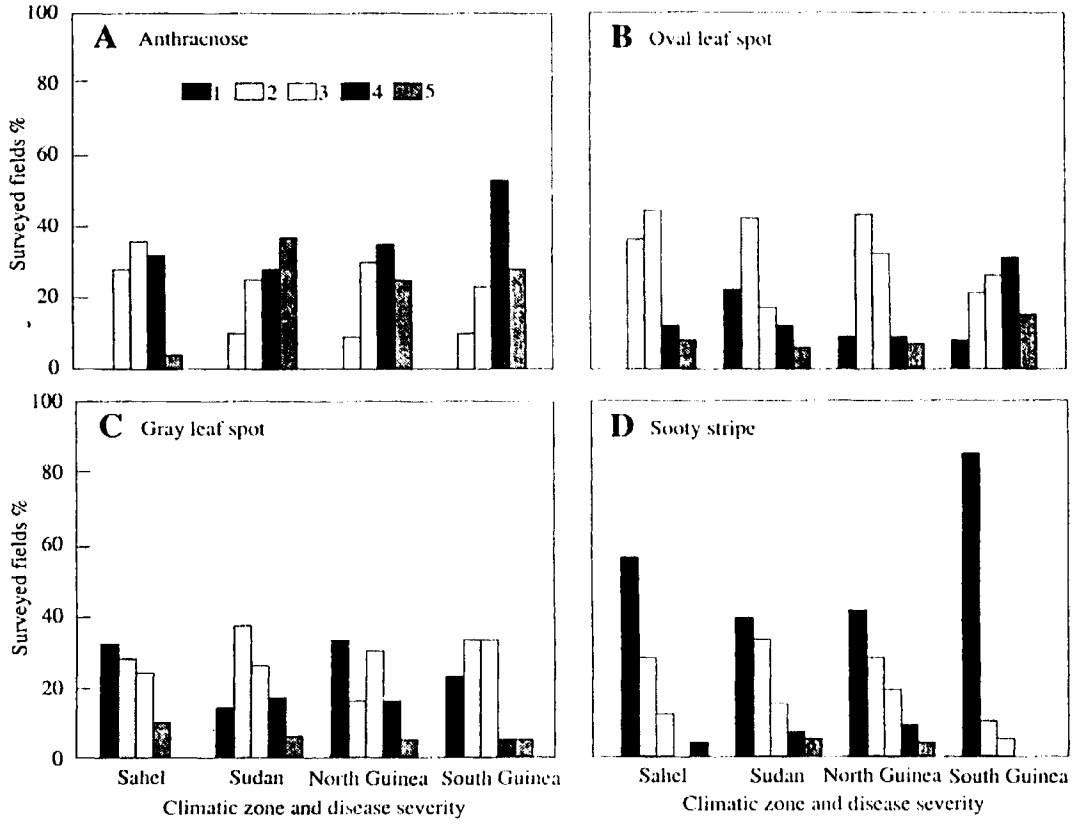

Figure 2. Severity of sorghum anthracnose, oval leaf spot, grey leaf spot and sooty stripe diseases in surveyed field (%) in four climatic zones of Nigeria, crop season 1990. Leaf disease severity based on a 1–5 rating scale, where 1 = no lesions, 2 = 1–5%, 3 = 6–20%, 4 = 21–40% and 5 = >40% leaf area damaged by the disease lesions.

adsorbed with healthy leaf extract as described by Hobbs *et al.*, 1987. Optical density readings were taken at 620 nm wavelength. Absorbance values were considered positive if they yielded values double the mean optical density values of healthy plant extracts. At least 38 samples (except in Sahel) showing virus disease symptoms, and two symptomless samples, were processed from each climatic zone and identified at the ICRISAT Centre, India.

3. Results

Occurrence of the dominant sorghum diseases in four climatic zones of Nigeria is given in Figure 2.

3.1. Foliar diseases caused by fungi

3.1.1. Anthracnose [Colletotrichum graminicola *(Ces.), G. W. Wilson*]. Anthracnose was the most predominant and widely distributed foliar disease of sorghum in the Sahel, Sudan, northern Guinea and southern Guinea zones of Nigeria. The disease was observed in >95% of the surveyed fields and was severe (3–5, on a 1–5 rating scale) in >70% farmers' fields (Figure 2A). Local sorghum landrace cultivars and improved sorghum introductions were susceptible to foliar anthracnose. In general disease severities were lower in the Sahel than in the other three zones (Figure 2A).

3.1.2. Oval leaf spot (Ramulispora sorghicola *Harris.*). This disease was second in prevalence to anthracnose and was present in 85% of the surveyed fields. Symptoms were characterized by semicircular or roughly circular lesions with pinkish grey to straw-coloured centres and conspicuous dark red or tan borders, but without acervuli. Disease severities varied from 1 to 5; however, 50% of the surveyed fields had severities between 3 and 5. Local sorghum landrace cultivars appeared to be more susceptible to this disease than improved cultivars. Disease incidence and severity were higher in the Sahel and southern Guinea than in the Sudan and northern Guinea zones (Figure 2B). In the Sahel zone in two fields, oval leaf spot attacked sorghum at an early growth stage (seven to eight fully expanded leaf stage) and considerable leaf area (>70%) was destroyed.

3.1.3. Grey leaf spot (Cercospora sorghi *Ell. and Ev.*). Grey leaf spot was the third most common disease with an incidence of >70% in all four climatic zones. It caused extensive foliar damage in the Sudan and northern Guinea zones on both local and improved sorghums, where leaf sheaths and upper stems were also found infected. Disease severities were 3–5 in 50% of the surveyed fields in Sudan and northern Guinea zones, while in Sahel and southern Guinea disease was severe (3–5) in 34% and 43% of fields, respectively (Figure 2C). Most of

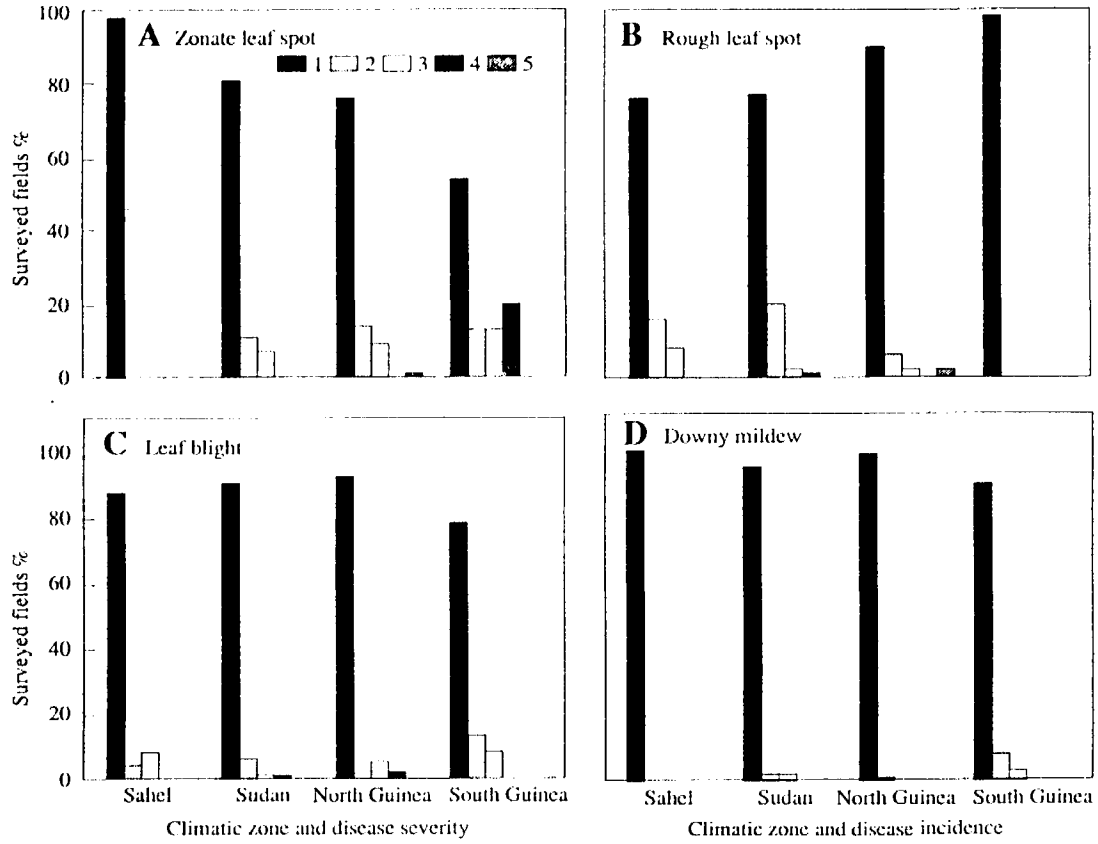

Figure 3. Severity of sorghum zonate leaf spot, rough leaf spot and leaf blight, and percentage incidence of downy mildew in surveyed fields (%) in four climatic zones of Nigeria, crop season 1990. Leaf disease severity based on a 1–5 rating scale, where 1 = no lesions, 2 = 5%; 3 = 6–20%; 4 = 21–40% and 5 = >40% leaf area damaged by the disease lesions. Downy mildew incidence based on 1–5 rating scale where 1 = no diseased plant; 2 = 1%; 3 = 2–5%; 4 = 6–10% and 5 = >10% plants infected with systemic infection.

the local landrace cultivars were susceptible to grey leaf spot.

3.1.4. Sooty stripe [Ramulispora sorghi *(Ell. and Ev.) L.S. Olive and Lefebvre*]. This disease occurred at all sorghum growth stages from flowering through maturity in most of the surveyed fields. Disease incidence was >60% in the northern Guinea and the Sudan, with foliar damage (severity rating of 3–5) of 27%, and 32% of the surveyed fields, respectively. Sooty stripe was observed less frequently in southern Guinea and Sahel, where only 5% and 16% of the surveyed fields, respectively had severity ratings of 3–5 (Figure 2D).

3.1.5. Zonate leaf spot (Gloeocercospora sorghi *D. Bain Edg.*). Zonate leaf spot occurred in 18%, 24% and 46% of the surveyed fields in the Sudan, northern Guinea and southern Guinea zones, respectively. The disease was not observed in the Sahel. Disease severities were between 3 and 5 in 33% of fields in southern Guinea zone. In Sudan and northern Guinea zones up to 10% fields had disease severity equivalent to southern Guinea (Figure 3A).

3.1.6. Rough leaf spot (Ascochyta sorghina *Sacc*). Rough leaf spot was found on sorghum at all growth stages. The disease was conspicuous in the Sahel, particularly in fields where sorghum was in post-flowering growth stages, and was predominant on lower leaves. Though rough leaf spot was observed in 10–24% of the fields in Sahel, Sudan and northern Guinea zones of Nigeria, its severities were low in these zones and only 3–8% of the total fields had disease severities of 3–5. This disease was not observed in southern Guinea. Highest incidence and severity of rough leaf spot were recorded in Sahel (Figure 3B).

3.1.7. Leaf blight [Exserohilum turcicum *(Pass.) Leonard and Suggs*]. Leaf blight incidence ranged from 7% to 21% in the four climatic zones, and only 2–8% of fields had severities of 3–5 (Figure 3C).

3.1.8. Sorghum downy mildew [Peronosclerospora sorghi *(Weston and Uppal) C. G. Shaw*]. The incidence of downy mildew was low (0–5%). The disease occurred as systemic infection. Downy mildew was not observed in the Sahel (Figure 3D).

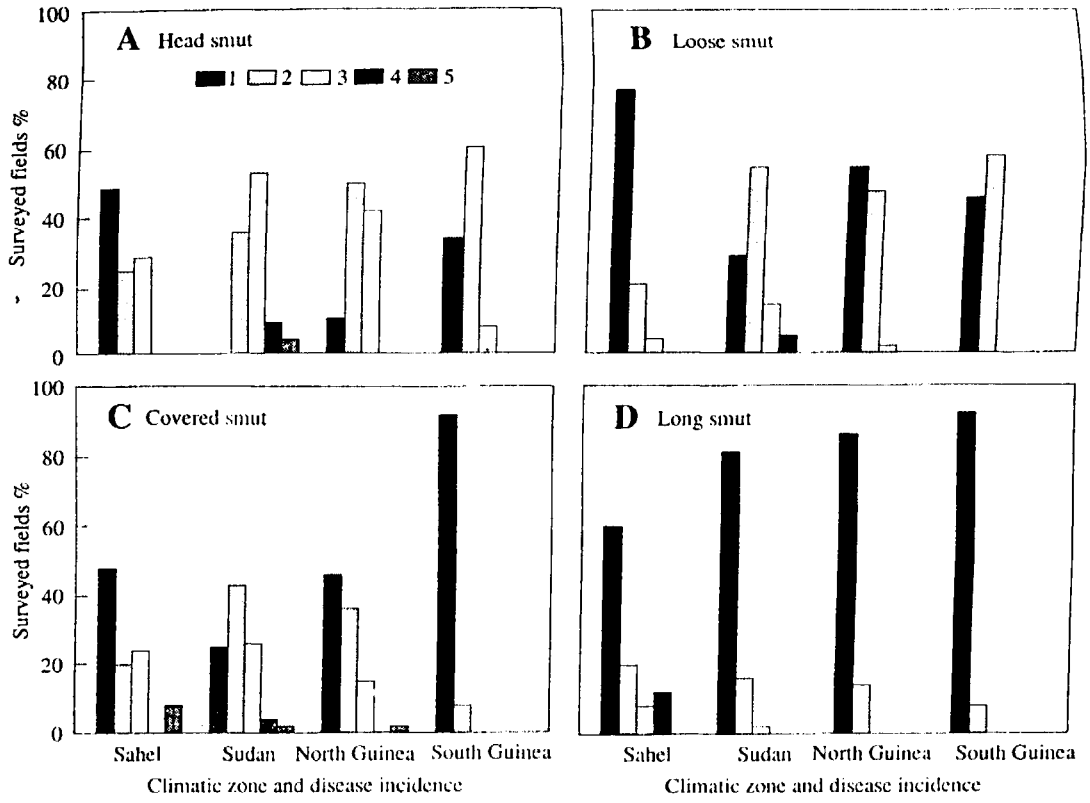

Figure 4. Incidence of head smut, loose smut, covered smut and long smut in surveyed fields (%) in four climatic zones of Nigeria, crop season 1990. Smut incidence based on a 1–5 rating scale, where 1 = no diseased plants; 2 = 1%; 3 = 2–5%; 4 = 6–10% and 5 = >10% plant head smut infection

3.2. *Virus diseases*

Out of 220 samples, exhibiting possible virus disease symptoms, that were processed using the ELISA test, 62 reacted positively to one of the three antisera developed for maize mosaic virus (MMV), maize stripe virus (MStV), and a potyvirus. Among the 37 positive detections from 99 samples in the northern Guinea zone, 27 belonged to MMV, six to potyvirus and two to mixed infection by MMV and a potyvirus, while another two showed MStV and potyvirus infection. Similarly, out of 38 samples from southern Guinea, 23 confirmed the presence of MMV and one had potyvirus. Only one sample out of 78 gave a positive indication of the presence of potyvirus in the Sudan zone, while all the five samples from the Sahel zone reacted negatively to ELISA tests, indicating the absence of the three viruses in the samples tested from this zone (Table 1). None of the plants taken as healthy controls showed positive reactions to any of the three antisera used.

3.3. *Panicle diseases caused by fungi*

3.3.1. Head smut [Sporisorium reilianum *(Kuhn) Langdon & Fullerton*]. Head smut was found in all four climatic zones. The disease incidence in individual fields ranged from 0% to 10%. Head smut incidence was considerably higher in the Sudan than in the other zones. In the Sudan 65% of the surveyed fields had ≥5% head smut infection (Figure 4A).

3.3.2. Loose kernel smut [Sphacelotheca cruenta *(Kuhn) Potter*]. Loose smut was observed in all the climatic zones. In 20% of farmers' fields, disease was observed on the panicles of tillers and not on the panicles of the main stem. Disease incidence ranged from 0% to 10%, but the majority of the fields had <5% smut infection (Figure 4B).

3.3.3. Covered kernel smut [Sporisorium sorghi *(Ehrenberg) Link*]. Covered smut was present in all sorghum-growing zones. In the Sudan 75% of fields had the disease, while in southern Guinea disease was found only in 8% of the fields, with an incidence of <1%. In the Sahel, Sudan and northern Guinea zones 17–32% of fields had <5% smutted plants (Figure 4C).

3.3.4. Long smut [Tolyposporium ehrenbergii *(Kuhn) Patouillard*]. Long smut was present in all the four sorghum-growing zones, and its incidence was the highest in the Sahel (40% of fields), while in the Sudan, northern Guinea and southern Guinea, 18%, 14% and 8% respectively, of the surveyed fields had the disease. In general long smut incidence was low (<1%) in most of the farmers' fields except in the Sahel, where 20% of the fields had 5–10% smutted plants (Figure 4D).

Table 1. Sorghum virus(es) disease(s) in Nigeria, rainy season 1990

Climatic zones	Sample no.	No. of samples indicating the presence of different viruses in ELISA test						
		MStV[a]	MMV[b]	MStV + potyvirus	MStv + MMV	MMV + potyvirus	Potyvirus	Total
Sahel	5	0	0	0	0	0	0	0
Sudan	78[c]	0	0	1	0	0	0	1
Northern Guinea	99[c]	0	27	6	0	2	2	37
Southern Guinea	38[c]	0	23	1	0	0	0	24
Total	220	0	50	8	0	2	2	62

[a]Maize stripe (maize stripe virus).
[b]Maize mosaic (maize mosaic virus).
[c]Many samples gave non-specific reactions in ELISA test, therefore those results were not considered.

3.4. Grain moulds, charcoal rot and bacterial diseases

Grain moulds, charcoal rot and diseases caused by bacteria were not observed in farmers' fields in this survey.

4. Discussion

Two decades ago, foliar diseases were considered of little economic importance in Nigeria (Anon, 1970, 1971). This may have been due to resistance in sorghum landrace cultivars grown by farmers. Low fertility, low plant populations, and intercropping characteristic of most sorghum production in Nigeria (Norman *et al.*, 1982), may have provided additional deterrents to the development of epiphytotics of foliar diseases in farmers' fields. However, with the changing crop husbandry practices (monocropping) and introduction of new high-yielding cultivars for increasing and stabilizing crop production, several leaf diseases appeared to become important (Tyagi, 1980). One released sorghum variety, Bauchi Early Selection (BES), was reported to be susceptible to anthracnose at research stations in Nigeria (Tyagi, 1980). During this survey BES and its sister lines were found extensively cultivated in the Sudan, northern Guinea and parts of southern Guinea zones of Nigeria. These BES cultivars were found to be highly susceptible to foliar anthracnose and grey leaf spot diseases of sorghum.

Although long-duration varieties were found with symptoms of anthracnose and grey leaf spot, the short-duration varieties were heavily attacked with disease severities between 3 and 5 on a 1–5 rating scale. Other foliar diseases causing severe damage were oval leaf spot and sooty stripe. Similarly, during this survey a high incidence of rough leaf spot and zonate leaf spot has been observed throughout Nigeria. Leaf blight and downy mildew were found to be of lesser economic importance.

The results of this survey supported earlier reports (Harris, 1963; Keay, 1968; King, 1972; Selvaraj, 1980) that smuts are the most important and widespread group of panicle diseases in the sorghum-growing areas of Nigeria. The relative importance of the four smuts does not appear to have changed since 1978 (Selvaraj, 1980). However, during this survey the incidence of long smut was higher in the Sahel than in the other three zones.

Research on sorghum smuts in Nigeria has been in progress since 1957 (Harris, 1963). Initial studies were carried out on routine disease diagnosis (Harris, 1963), recording outbreaks and estimation of crop losses due to smuts (Keay, 1968), mode of infection of the long smut (Manzo, 1976) and development of resistance screening technique (Selvaraj, 1980). Of the four smuts recorded on sorghum in Nigeria, loose smut and covered smut can be effectively controlled by seed treatment (El Hilu Omer and Frederiksen, 1992). However, there is further need to understand the biology of the pathogens causing head smut and long smut diseases in sorghum, so that an effective and repeatable resistance screening technique can be developed to identify the resistant material for utilization in future breeding programmes.

During this survey grain moulds were not observed, probably because the rains were insufficient for disease development, and did not last long enough, particularly during the grain development stage. Several grain moulds and associated fungi have been reported from Nigeria (Tyagi, 1980).

These survey results, based on the ELISA from plants showing virus-like symptoms, indicated the presence of three sorghum virus diseases for the first time in Nigeria (Table 1). However, the incidence of these viruses in farmers' fields was low (<1%). Several samples which resembled virus disease-like symptoms did not react with the three antisera tested, indicating the presence or absence of other virus diseases.

Downy mildew, leaf blight, zonate leaf spot, and rough leaf spot diseases were also observed in low intensities. Reasons for the low incidence of virus and these diseases in sorghum during the survey period may be attributed to several factors such as low fertility, low plant populations, mixed cropping systems, drought, crop growth stages (near physiological maturity). These diseases need further monitoring.

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