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A Survey of the Major Sorghum Production Regions for Foliar and Panicle Diseases during the 2022 Growing Season in Senegal, West Africa

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Abstract

Sorghum is a vital commodity and greatly contributes to the daily calorie needs for millions of the inhabitants in Senegal, West Africa. Yet, sorghum productivity and profitability are impacted by diseases. In the 2022 growing season, 122 farmers' fields across 7 regions, notably Diourbel, Fatick, Kaffrine, Kaolack, Kolda, Tambacounda, and Thies were surveyed for foliar and panicle diseases. During the survey, stops were made at 30 km intervals and at each stop, 2 - 5 fields were evaluated. In each field, 40 plants mostly at soft to early hard dough stages of development were assessed using a W-shaped pattern to cover the whole field. A total of 13 diseases, including leaf blight, anthracnose, Zonate leaf spot, Sooty stripe, rough leaf spot, oval leaf spot, long smut, grain mold, and covered kernel smut were documented. The most predominant diseases were leaf blight, anthracnose, and zonate leaf spot. The prevalence of leaf blight was 100%, while anthracnose and zonate leaf spot were found in 93 out of the 122 fields surveyed, indicating a 76% prevalence, respectively. Across the regions, the prevalence of rough leaf spot was 47%, covered kernel smut (32%), oval leaf spot (19%) and target leaf spot (19%). Mean incidence of leaf blight was high in all regions, ranging from 94% (Kaolack) to 100% (Fatick and Tambacounda). The highest mean incidence of anthracnose (62%) and covered kernel smut (16%) was noted in Tambacounda region. In the region of Thies, the highest mean incidence of zonate leaf spot (49%) was recorded. The mean severity of leaf blight (37%) was highest on plants assessed in the region of Kaffrine, followed by those in the regions of Kaolack, Tambacounda, and Kolda. Anthracnose infection was most intense on plants evaluated in Kolda, while zonate leaf spot was most severe in the region of Tambacounda.

Fields with incidences of 85% and above were considered as "hotspots" to evaluate sorghum germplasm for disease resistance. This survey is significant because the information obtained will be beneficial to plant pathologists, sorghum producers, government officials, and funding agencies to prioritize research projects that ensure productivity and food security.

Keywords

Sorghum, Survey, Sorghum Diseases, Incidence, Severity, Prevalence, Senegal

1. Introduction

Worldwide, sorghum ranks fifth behind maize, rice, wheat and barley in cereal hectarage and production [1] [2] [3]. During the 2021/2022 season, 40.8 million hectares were planted, resulting in a total production of 58.03 million metric tons [4]. In the arid and semi-arid regions of the world, sorghum plays a critical role in subsistence farming and supplies the daily calorie needs for hundreds of million people [1] [5] [6] [7]. In Africa south of the Sahara, 300 million inhabitants rely on the crop for food security [8]. In addition, sorghum uses are expanding from biofuel, production of paper, starch, and fiber to its utilization in pet food and its potential benefits for human health [3] [5] [6] [9] [10] [11] [12]. In Senegal, sorghum production is behind millet and maize among dryland cereals and plays a vital role in the lives of subsistence farmers [7] [13]. The 5-year mean (2017/2018 to 2021/2022) sorghum area planted was 250,000 ha and production of 302,000 tons [14]. During the same period, mean yield was 1.2 tons/ha in Senegal [14]. Sorghum yields in Senegal and some other African Countries continue to lag behind from the US, Argentina, Brazil, and Mexico due to several factors such as the parasitic weed striga, predation by birds prior to harvest, other pests, soil types, type of sorghum landraces, unpredictable weather patterns, preference of other cereals for consumption, and low farm inputs [1] [4] [15] [16]. By 2050, the world's population will increase to around 9 billion and concurrently, 3 billion tons increases in cereal production will be needed for food and other uses [1] [17]. Cereal production increases coupled with climate change will surely increase fungal and other microorganisms [18]. As a result, disease control will have to be part of an integrated management strategy to ensure increases in cereal and other crops' production [18]. In 2019, survey conducted in Senegal identified 16 different sorghum diseases across 7 production regions [18]. To validate the information gathered in 2019, a second survey was conducted in 2022. In this study, the incidence, prevalence, and severity of sorghum foliar and panicle diseases across farmers' fields in the 7 major sorghum production regions were investigated.

2. Materials and Methods

Study area: Field survey of sorghum foliar and panicle diseases was conducted across 7 major production regions of Diourbel, Fatick, Kaffrine, Kaolack, Kolda, Tambacounda, and Thies in Senegal, West Africa, during the 2022 growing season (**Figure 1**). Senegal lies between latitudes 12˚30' and 16˚30'N and longitudes 11˚30' and 17˚30'W, with the northern part of the Country lying in the Sahelian zone, while the wetter southern part in the Sudanian zone [19].

The rainy season lasts for 3 to 4 months and thereafter, a long dry period [20] [21]. Among the regions surveyed, Diourbel (772.3 mm) in the west part of the country receives the lowest while Kolda (1340.1 mm) in the southern part receives the highest annual rainfall (**Table 1**). The soil types in the regions consisted of cambisols, arenosols, gleysols, regosols, acrisols, lixisols, and solonchacks either individually or in combination [18] (**Table 2**). Sorghum cultivation in the country is mainly by rainfed.

Data collection: The protocol for data collection was previously described by Prom *et al.* [18]. Briefly, sorghum fields located along paved and unpaved roads and around rural villages were surveyed during the 2022 growing season. A total of 122 farmers' fields across the 7 regions were surveyed, using a W-shaped pattern to cover the whole field. Stops were made at 30 km intervals and at each stop, 2 - 5 fields (40 plants/field) were assessed for foliar and panicle diseases. Plants in most of the fields surveyed were at soft to early hard dough stages of development.

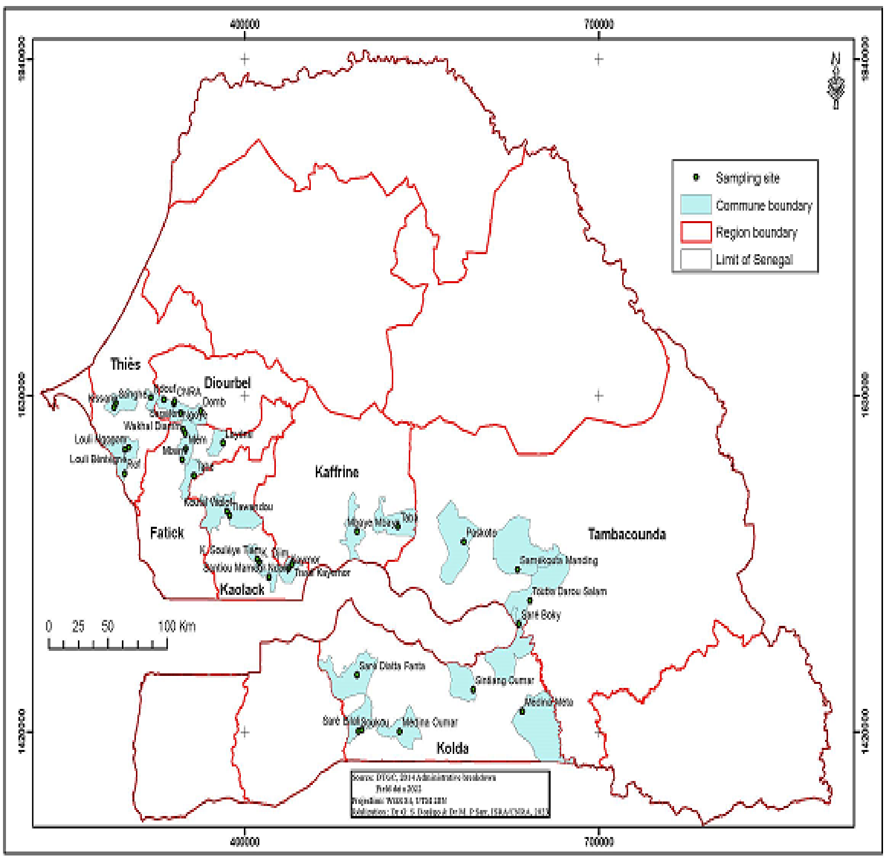

Figure 1. Map of the regions and locations of the surveyed area.

Table 1. Rainfall, temperature and relative humidity of the surveyed regions during the 2022 growing season.

Mean weather parameters (May to October)				
Region	Rainfall (mm)	Max Temp (˚C)	Min Temp (˚C)	Relative humidity (%)
Diourbel	772.3	36	24.7	71
Fatick	1215	31	25.7	82.2
Kaffrine	1254	34	24.5	83.5
Kaolack	851.6	34.2	25	74
Kolda	1340.10	33.50	23.5	76
Tambacounda	935.9	34.5	24.8	57
Thies	744	34.2	22.3	77.4

Source: ANACIM and ISRA, 2022.

Table 2. Climate and soil type of the surveyed regions.

Data	Regions						
	Thies	Diourbel	Fatick	Kaolack	Kaffrine	Tambacounda	Kolda
Climate	Sahelo-Soudanian with an annual rainfall between 300 and 600 mm	Sahelo-Soudanian with an annual rainfall between 300 and 600 mm	Sahelo-Soudanian with an annual rainfall between 600 and 1000 mm	Soudanian with an annual rainfall between 600 and 1000 mm	Soudanian with an annual rainfall between 600 and 1000 mm	Soudanian with an annual rainfall between 600 and 1200 mm	Soudano-Guinean with annual rainfall between 1000 and 1200 mm
Soil type	Cambisols Arenosols Gleysols	Cambisols Arenosols	Cambisols	Arenosols Lixisols Regosols Solonchacks	Arenosols Lixisols Regosols Gleysols	Regosols Gleysols Acrisols	Acrisols Gleysols

Source: Major climatic area, (IRD 1988) and world soil databases.

Equations for prevalence and incidence as per Prom *et al.* [18] [22].

$$\text{Prevalence rate} = \frac{\text{Number of fields with the disease}}{\text{Total number of surveyed fields}} \times 100$$

$$\text{Incidence} = \frac{\text{Number of plants with the disease in a field}}{\text{Number of plants assessed in a field.}} \times 100$$

Disease Severity scale: The severity scale was previously described by Prom *et al.* [22] and based on 0 - 11 with their mid-points, where 1 = 5.5, 2 = 15.5, 3 = 25.5, 4 = 35.5, 5 = 45.5, 6 = 55.5, 7 = 65.5, 8 = 75.5, 9 = 85.5, 10 = 95.5, and 11 = 100 used to calculate the mean severity.

3. Results

During the 2022 growing season, a survey of foliar and panicle diseases from 122 fields in 7 major sorghum production regions of Diourbel, Fatick, Kaffrine, Kaolack, Kolda, tambacounda, and Thies in Senegal, West Africa was conducted. The surveyed fields were primarily planted with different landraces with few exceptions planted with advanced/improved varieties developed and released by Institut Sénégalais de Recherches Agricoles/Centre National de Recherches Agronomiques (ISRA/CNRA). Notably, different production systems and sorghum types were employed by the producers, ranging from pure sorghum stands to intercropping with okra, peanuts, and cowpea with short and long stems. Field sizes ranged from 0.25 to 2.5 ha and were relatively free of weeds. The mean rainfall in millimeters, temperatures, and relative humidity during the survey period in 2022 is listed in **Table 1**. The soil type of the fields surveyed in Fatick region consisted of cambisols; whereas the remaining regions of Diourbel, Kaffrine, Kaolack, Kolda, Tambacounda, and Thies consisted of various mixtures of cambisols, renosols, glysols, regosols, acrisols, lixisols, and solonchacks (**Table 2**). The area planted, yield, and production during the 2022-2023 cropping season for the surveyed regions are noted in **Table 3**.

In the survey, 40 plants per field were assessed for foliar and panicle diseases using a W-shaped pattern to cover the entire field. Across the 122 fields surveyed, 13 diseases leaf blight (**Figure 2(a)**), anthracnose (**Figure 2(b)**), Zonate leaf spot (**Figure 2(c)**), Sooty stripe (**Figure 2(d)**), rough leaf spot (**Figure 3(a)**), oval leaf spot (**Figure 3(b)**), long smut (**Figure 3(c)**), covered kernel smut (**Figure 3(d)**), bacterial leaf stripe, target leaf spot, bacterial leaf streak, grain mold, and gray leaf spot were documented (**Table 4**). The most identified diseases were leaf blight, anthracnose, and zonate leaf spot. Plants infected with leaf blight (100%) were detected in all surveyed fields, while anthracnose and zonate leaf spot were found in 93 out of the 122 fields surveyed, resulting in 76% prevalence, respectively, during the 2022 growing season (**Table 4**). The prevalence of rough leaf spot across the 7 regions was 47%, covered kernel smut (32%), gray leaf spot (20%), and 19% for oval leaf spot and target leaf spot, respectively. Out of the 122 fields surveyed, bacterial leaf stripe was found in 7 fields, long smut in four fields, and bacterial leaf streak in two fields.

Table 3. Preliminary results for the 2022-2023 crop year—Summary of sorghum crop.

Sorghum			
Region	Area (ha)	Yield (kg/ha)	Production (T)
Diourbel	589	885	521
Fatick	15,099	813	12,279
Kaffrine	64,775	1687	109,267
Kaolack	9562	698	6673
Kolda	42,938	1295	55,587
Tambacounda	2413	401	967
Thies	14,758	859	12,681
Average of the last five years (Senegal)	250,265	1207	302,184

Source: MAER/DAPSA, Monthly Bulletin of Economic and Financial Statistics (January 2023).

(a) (b) (c) (d)

Figure 2. (a) Leaf blight; (b) Anthracnose; (c) Zonate leaf spot; (d) Sooty stripe.

(a) (b) (c) (d)

Figure 3. (a) Rough leaf spot; (b) Oval leaf spot; (c) long smut; (d) Covered kernel smut.

Among the regions surveyed, leaf blight infected plants were detected in all fields (**Table 5**). The prevalence of anthracnose and zonate leaf spot was 100% in the region of Tambacounda, followed by Kolda region with 89%. In the region of Kaffrine, the prevalence of anthracnose was also 100%. Rough leaf spot (71%) was most prevalent in Tambacounda region, followed by the region of Kaolack with 60%. The occurrence of sooty stripe (47%) was highest in the regions of Kaolack and Kolda. The highest prevalence of gray leaf spot (53%), oval leaf spot (42%), target leaf spot (37%), covered kernel smut (37%), and bacterial leaf stripe (11%) was recorded in the region of Kolda. Sorghum long smut was recorded only in the region of Fatick with 20% prevalence, while bacterial leaf streak was observed in Diourbel and Kaolack regions (**Table 5**).

Mean incidence of leaf blight was high in all regions, ranging from 94% to 100% (**Table 6**). The highest mean incidence of anthracnose (62%) and covered kernel smut (16%) was noted in Tambacounda region. In the region of Thies, the highest mean incidence of zonate leaf spot was recorded. Mean incidences of oval leaf spot (27%) and gray leaf spot (25%) were highest in the region of Kolda, whereas the highest mean incidence of target leaf spot was observed in Kaffrine region.

Table 4. Prevalence of the various sorghum diseases observed across 122 production fields in Senegal, West Africa, 2022[1].

Disease	Fields with disease (%)
Anthracnose (*Colletotrichum sublineola*)	76
Bacterial leaf stripe (*Burholderia andropogonis*)	6
Long smut (*Sporisorium ehrenbergii*)	3
Oval leaf spot (*Ramulispora sorghicola*)	19
Leaf blight (*Exserohilum turcicum*)	100
Target leaf spot (*Bipolaris sorghicola*)	19
Bacterial leaf streak (*Xanthomonas campestris* pv. *holcicola*)	2
Sooty stripe (*Ramulispora sorghi*)	32
Covered smut (*Sporisorium sorghi*)	14
Rough leaf spot (*Ascochyta sorghina*)	47
Gray leaf spot (*Cercospora sorghi*)	20
Grain mold (Various fungal genera)*	16
Zonate leaf spot (*Gloeocercospora sorghi*)	76

[1]Sorghum fields from the major sorghum growing regions of Diourbel, Fatick, Kaffrine, Kaolack, Kolda, Tambacounda, and Thies were surveyed. *The lower prevalence of grain mold may be attributed to the fact that some of the surveyed plants were at the late flowering early soft dough stage of development.

Table 5. Percent prevalence of sorghum diseases observed in the five regions surveyed during the 2022 growing season in Senegal, West Africa[1].

Disease	Diourbel	Fatick	Kaffrine	Kaolack	Kolda	Tambacounda	Thies
Anthracnose	48	60	100	87	89	100	70
Leaf blight	100	100	100	100	100	100	100
Zonate leaf spot	52	70	80	87	89	100	65
Oval leaf spot	24	15	20	27	42	6	0
Rough leaf spot	38	35	50	60	42	71	45
Sooty stripe	29	10	40	47	47	24	35
Target leaf spot	14	10	10	13	37	35	10
Long smut	0	20	0	0	0	0	0
Covered kernel smut	5	20	10	0	37	29	0
Grain mold	10	15	0	7	37	0	30
Bacterial leaf stripe	10	10	0	0	11	6	0
Bacterial leaf streak	5	0	0	7	0	0	0
Gray leaf spot	19	0	0	40	53	12	15

[1]Number of surveyed fields in each region: Diourbel = 21 fields; Fatick = 20 fields; Kaffrine = 10 fields; Kaolack = 15; Kolda = 19 fields; Tambacounda = 17; and Thies = 20 fields. In each field, 40 plants were evaluated using a W-shaped pattern.

Table 6. Percent mean incidence and severity of sorghum diseases observed across production fields in seven regions during the 2022 growing season in Senegal, West Africa[1].

Region	AN		LB		ZON		OLS		RL		SOOT		TAR	
	Inc[2]	Sev[3]	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev
Diourbel	20	10	98	32	11	7	4	5	36	15	7	7	8	21
Fatick	29	8	100	31	28	7	6	6	16	7	6	7	3	11
Kaffrine	49	9	97	37	38	13	13	11	15	9	6	6	13	6
Kaolack	37	8	94	35	22	9	9	7	37	13	18	7	6	36
Kolda	50	15	99	33	18	9	27	13	14	12	17	12	11	10
Tambacounda	62	14	100	34	48	15	3	6	30	13	9	10	8	8
Thies	39	8	99	25	49	10	0	0	37	9	28	9	6	9

	LS		CS		GM		BLS		BSK		GLS	
	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev	Inc	Sev
Diourbel	0	0	8	12	18	7	3	16	3	6	4	6
Fatick	19	13	12	31	48	19	3	36	0	0	0	0
Kaffrine	0	0	3	6	0	0	0	0	0	0	0	0
Kaolack	0	0	0	0	35	17	0	0	3	6	21	7
Kolda	0	0	15	23	15	14	3	36	0	0	25	11
Tambacounda	0	0	16	23	0	0	3	66	0	0	9	11
Thies	0	0	0	0	52	18	0	0	0	0	5	6

[1]Number of surveyed fields in each region: Diourbel = 21 fields; Fatick = 20 fields; Kaffrine = 10 fields; Kaolack = 15; Kolda = 19 fields; Tambacounda = 17; and Thies = 20 fields. In each field, 40 plants were evaluated using a W-shaped pattern. AN = Anthracnose; LB = Leaf blight; ZON = Zonate leaf spot; OLS=Oval leaf spot; RL = Rough leaf spot; SOOT = Sooty stripe; TAR = Target leaf spot; LS = Long smut; CS = Covered kernel smut; GM = Grain mold; BLS = Bacterial leaf stripe; BSK = Bacterial leaf streak; and GLS = Gray leaf spot. [2]Inc = percent incidence; [3]Sev = percent severity.

The mean severity of leaf blight (37%) was highest on plants assessed in the region of Kaffrine, followed by those in the regions of Kaolack (35%), Tambacounda (34%), and Kolda (33%) (**Table 6**). Anthracnose infection was most intense on plants evaluated in Kolda (15%) followed by Tambacounda (14%). Diseases such as zonate leaf spot (15%) were most severe in the region of Tambacounda, target leaf spot (21%) in Diourbel, oval leaf spot (13%) in Kolda, and gray leaf spot (11%) in the regions of Kolda and Tambacounda, respectively.

During the survey, disease hotspots that can be utilized to evaluate sorghum germplasm for resistance were identified. In Senegal, locations such as Altou Fass koto, Medina Taif, Sinthian Omar, and Samikounta Mandinko are ideal places where resistance screening against pathogens, causing leaf blight and anthracnose can be conducted (**Table 7** and **Table 8**). In addition, five locations in three regions Kaffrine, Tambacounda, and Thies can be considered as hotspots for zonate leaf spot resistance evaluation sites (**Figure 4**).

Table 7. Regions and selected location of fields with 100% percent incidence ("hot spots") of leaf blight.

Region	Field #	Location
Diourbel	3	Ndangalma
	5	Sagaleme
	9	Ngoye
	20	Nomb
Fatick	2	Wakhal Diam
	4	Meme
	11	Tabe
Kaffrine	2	Yoba
	6	Medina Taif
	7	Medina Taif
	9	Taba
Kaolack	3	Ndaffane
	5	Keur Souleye Thiam
	6	Santhie Mamour N'dary
	10	Kaymor
Kolda	8	Sinthian Omar
	9	Medina Omar
	12	Sare Bilali
	14	Sare Bilali
	16	Medina Metaba
Tambacounda	3	Altou Fass Koto
	4	Altou Fass Koto
	7	Samikounta Mandinko
	10	Samikounta Mandinko
	14	Touba Darou Salam
	17	Touba Darou Salam
Thies	5	Kissane
	8	Sangue
	17	Ndour
	18	Klouck
	20	Fane

In each field, 40 plants were assessed using the w-shape pattern to cover the whole field.

Table 8. Regions and selected location of fields with 85% percent incidence ("hot spots") of anthracnose.

Region	Field #	Location
Kaffrine	8	Medina Taif
	10	Medina Taif
Kaolack	6	Santhie Mamour N'dary
	9	Kaymor
Kolda	8	Sinthian Omar
	10	Sinthian Omar
	11	Sinthian Omar
	16	Medina Metaba
Tambacounda	2	Altou Fass Koto
	6	Samikounta Mandinko
	8	Samikounta Mandinko
	10	Samikounta Mandinko
Thies	10	Roff
	20	fane

In each field, 40 plants were assessed using the w-shape pattern to cover the whole field.

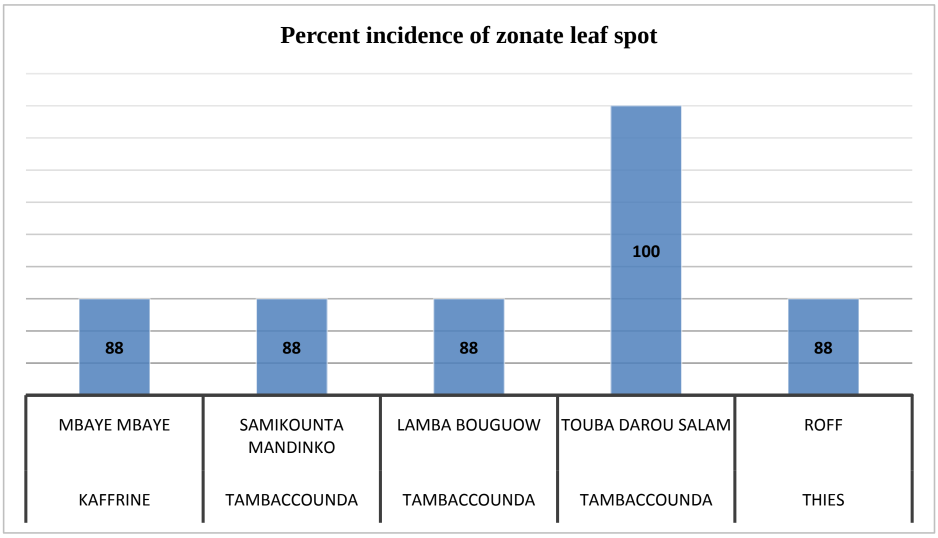

Figure 4. Zonate leaf spot "hot spot" in three regions, Kaffrine, Tambacounda, and Thies for resistance evaluation of sorghum germplasm.

4. Discussion

Climate change and the expected increase in global population to around 9.1 billion inhabitants by 2050 will require increases in cereal production, including sorghum, a versatile crop that is well adapted in marginal agro-ecological zones [5] [15] [17] [23] [24]. Yet, sorghum productivity and profitability are negatively impacted by fungal, bacterial, viral, and other microorganisms [18]. And without increases in land use/space, other management options to increase yields such as the use of resistant sources will have to be implemented. The initial step in implementing a robust and sustainable management strategy is to determine the occurrence, distribution, and the economic importance of plant diseases.

In this study, 122 fields in 7 major sorghum production regions of Diourbel, Fatick, Kaffrine, Kaolack, Kolda, Tambacounda, and Thies in Senegal, West Africa were surveyed for foliar and panicle diseases during the 2022 growing season. The work documented 13 diseases, including anthracnose, long smut, oval leaf spot, leaf blight, target leaf spot, bacterial leaf streak, sooty stripe, covered kernel smut, rough leaf spot, and zonate leaf spot (**Table 4**). Leaf bight incited by *Exserohilum turcicum* was the most prevalent disease and detected in all the surveyed fields, followed by anthracnose and zonate leaf spot with 76% prevalence, respectively. These results confirmed the survey of 206 farmers' fields across the same 7 major sorghum production regions in Senegal conducted in 2019, where leaf blight (96%), followed by anthracnose (68%), and zonate leaf spot (61%) were the most prevalent diseases [18]. In addition, a survey of 96 farmers' fields in 2022 in Niger, noted the presence of leaf blight infected plants in all surveyed fields, followed by anthracnose with 81% prevalence [22]. Also, leaf blight was detected in all 45 sorghum fields surveyed for diseases in Central Sudan [25]. Prom *et al.* [24] surveyed 121 sorghum fields in Niger during the 2019 growing season and recorded that anthracnose (99%) was the most prevalent disease followed by leaf blight (89%). Furthermore, 384 sorghum fields surveyed in lower Eastern Kenya revealed the presence of anthracnose in 272 fields and leaf blight in 270 fields [26]. Sorghum disease surveys conducted by Njoroge *et al.* [27] in Tanzania and Uganda, revealed that leaf blight and rust were the most detected diseases in Tanzania, while anthracnose and zonate leaf spot were the dominant diseases detected in Uganda. Sorghum anthracnose (93.7%) and leaf blight (84.8%) were reported to be the most prevalent diseases in South Tigray, Ethiopia, while anthracnose infected plants were observed in all 117 fields surveyed in Southwestern and Western Ethiopia [28] [29]. Ngugi *et al.* [30] reported that anthracnose, leaf blight, gray leaf spot, and zonate leaf spot were the most observed diseases on sorghum in Western Kenya. However, low frequency of leaf blight was reported in three climatic zones in major sorghum producing area in Ghana [31]. Nevertheless, these studies suggested that leaf blight, anthracnose, and zonate leaf spot are of economic importance and widespread in Africa, south of the Sahara. In this survey, the prevalence of leaf blight in all 7 regions was 100%, while the prevalence of anthracnose and zonate leaf spot was 100% in the region of Tambacounda (**Table 5**). Also, prevalence of anthracnose in the region of Kaffrine was 100%. The mean incidence of leaf blight among the regions surveyed in 2022 ranged from 94% in Kaolack to 100% in Fatick and Tambacounda, respectively (**Table 6**). Mean incidence of anthracnose ranged from 20% in Diourbel to 62% in Tanbacounda, whereas the region of Thies recorded the highest mean incidence of zonate leaf spot (49%). In three districts of South Omo and Seen People zones in Ethiopia, Eshte *et al.* [32] reported a mean incidence of 100% anthracnose infected plants. In this survey, intensity of leaf blight was highest in the region of Kaffrine (37%), followed by Kaolack with 35% and Tambacounda with 34% (**Table 6**). Anthracnose infection was most severe in the regions of Kolda and Tambacounda

The results of this current survey in Senegal, West Africa, confirmed and validated the information gathered in 2019 on the occurrence and distribution of foliar and panicle diseases in the same 7 major producing regions. During the 2019 survey, 15 different diseases anthracnose, bacterial leaf blight, bacterial leaf stripe, long smut, oval leaf spot, leaf blight, target leaf spot, bacterial leaf streak, sooty stripe, grain mold, covered kernel smut, rough leaf spot, gray leaf spot, zonate leaf spot, and maize mosaic virus were documented [18]. In Senegal, breeding for grain mold resistance is a top priority [33]. In the 2019 and 2022 surveys, the prevalence of grain mold was low because most of the plants were assessed at soft dough stage to early hard dough stage. In both surveys, leaf blight, anthracnose and zonate leaf spot were the most prevalent diseases across the regions [18]. However, there were also some differences between the two survey periods. In the 2019 survey, prevalence of leaf blight was 100% in the regions of Kolda, Kaolack, and Fatick, whereas in the 2022 survey, the prevalence of leaf blight was 100% in all regions. Disease severity was recorded during the 2022 survey but not in the 2019 survey [18]. Contrary to the 2019 survey, bacterial leaf blight and maize mosaic virus were not detected during the 2022 survey. Except for these two diseases, all other sorghum diseases were the same for the two survey periods. Loose kernel smut caused by *Sporisorium cruentum* was observed on sorghum planted on experimental plots in Bambey, Senegal, during the 2022 survey (Louis K. Prom and Mame Penda Sarr). This disease was not observed in the 2019 survey. At present, literature research is ongoing to determine whether this disease has ever been reported in Senegal.

Quantifying severity is a critical component in the ability to estimate yield loss and the relative economic impact of the disease. Disease severity was documented in the 2022 survey but not during the 2019 survey. The mean severity of leaf blight (37%) was highest in the region of Kaffrine, followed by Kaolack, Tambacounda, and Kolda, while anthracnose, zonate leaf spot, oval leaf spot, and gray leaf spot infections were most intense on plants evaluated in Kolda and Tambacounda.

In Senegal, sorghum is an important cereal; however, yields are low in most farmers' fields due to several factors, including diseases. Even so, changes in weather patterns can influence the presence and distribution of diseases [34]. Prom *et al.* [34] noted that frequent rains will increase anthracnose infection. Nevertheless, information about the occurrence and distribution of sorghum diseases in Senegal is vital to prioritize research projects. Furthermore, the best management strategy to control these diseases is to identify sorghum germplasm that are resistant and introgress the resistance genes into elite or adapted lines ([35]. However, food and energy cost are increasing in many African countries, including Senegal. In Africa, cereal importation exceeds 100 million metric tons annually [36]. The recent war in Ukraine is having a negative impact on supplies because most of the cereals are imported from either Russian Federation or Ukraine [36].

5. Conclusion

This work validated and confirmed that leaf blight, anthracnose, and zonate leaf spot are the most widespread and significant foliar sorghum diseases in Senegal, West Africa. Utilization of resistant sources is the best management strategy for plant diseases. Herein, "hotspots" for evaluating sorghum germplasm for disease resistance were identified. With the expected increase in global population growth and climate change, increases in sorghum production will be an integral part in ensuring food security, especially in the drier tropics. Knowledge gained from this survey will be beneficial to plant pathologists, breeders, students, sorghum producers, government officials, and funding agencies in determining research priorities to ensure productivity and sustainability in sorghum.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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