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Research Article

Distribution and Relative Importance of Black Sigatoka of Banana in Major Banana Production Areas of Ethiopia

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ABSTRACT

Banana plays an important role for food security, income generation for small holders and also source of foreign currency as export commodity. In Ethiopia large scale cultivation of banana is mainly found in Bench-Maji, Gamo Gofa, Jimma, Sidamo and Upper Awash. Survey was conducted in 2016 in major banana growing areas of Ethiopia. The survey confirmed that in all assessed areas banana orchards were infested by black sigatoka in different magnitude ranged from 12-80%. This result shows that almost all assessed field were caused by black sigatoka. Recent assessment result indicates that, 100% diseases incidence was recorded in Jimma and East Wollega Zones. In Kersa district of Busa Bechena kebele, 75% black sigatoka severity was recorded as a highest disease severity in 2021 growing season. During the 2016 growing season, the highest black sigatoka severity was recorded 80% in Gura Ferda district of Bench Maji Zone. This indicates that black sigatoka is important disease of banana which did not get attention in banana production system. Based on field symptomatic assessment as well as cultural and morphological characterization, *Mycospherella fijiensis* was identified as causal agent of the disease and threatening banana production in the surveyed areas. These findings provide information on the magnitude of the damage due to black sigatoka disease and will be useful to devise disease management strategies. It is necessary to investigate the reactions of the available banana cultivars against the pathogen and select disease tolerant banana materials.

Keywords: Black sigatoka; *Mycospherella fijiensis*; Banana; Spatial distribution

INTRODUCTION

Banana is one of the most important and a leading crop in the world agricultural production and trade. This fruit plays an important role for food security, income generation for smallholder farmers and also source of foreign currency as export commodity. Available estimates indicate that average global banana production is from 69 million tons in 2000-2002 to 115 million tons in 2017-2019, at an approximate value of 40 billion USD [1]. In Ethiopia it accounts the leading export fruits where the area under fruit production has been slightly expanding where about 90,070.83, 104,421.81 and 116,284.63 hectares of land was under fruit crops during 2015, 2018 and 2020 respectively [2]. The contribution of bananas is also showing an increasing trend where 59.64%, 63.49% and 63.94% for the year of 2015, 2018 and 2020 respectively of the fruit crop area in the country [2].

Despite its importance there are different types of production constraints and banana diseases such as Sigatoka, Fusarium wilt, Cigar-end rot, Bacterial wilt, Banana streak viruses, Banana mosaic virus, Banana bunchy top virus and root-knot nematodes is among major biotic factor affecting banana production worldwide including Ethiopia. In Ethiopia, Black sigatoka was detected severely in 2016 in potential banana producing districts.

Experiences from other countries showed that black sigatoka has been considered as the most damaging and costly disease of banana and plantain [3]. It has been estimated that the disease causes greater than 38% yield loss on plantain [4], and even greater losses may occur on export bananas when control measures fail. Both growth and yield are affected because of the reduction in the photosynthetic area [5]. Therefore, it is important to have the detailed information of black sigatoka disease occurrence, distribution and relative importance in major banana production areas of Ethiopia. Disease occurrence, development and damage to crops is influenced by cropping systems and production practices, crop genotypes, altitudinal ranges, cropping areas and field management practices under a given environment.

The objective of this study was to determine the spatial distribution of banana black sigatoka and its association with different agro-ecological variables, cropping systems and farmer's cultural practices.

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MATERIALS AND METHODS

Description of study areas

The survey was conducted in the major banana growing areas of the South Nation, Nationality and People (SNNP) regional state; Gamo Gofa, Sidamo and Bench Maji; Oromia regional state; Jimma, Wollega, West Shewa and Upper Awash farm. The altitude of the area ranges from 1074 m-2016 m above sea level. Selection of major banana producing areas was through Zonal Agricultural bureaus of respective zones. Survey areas were; Bench Maji (Gurra Farda, Semen Bench and Debub Bench), Gamo Gofa (Arba minch Zuriya, Darimalo and Merab Abaya), Sidamo (Dale, Aleta Wondo and Aleta Cuko), Upper Awash and Jimma (Sokorru, Seqa and Shebe) zones.

Sampling methods and data collection

A total of 14 major banana producing districts were selected and a total of 144 farmer's field were assessed randomly during 2016 and also quick assessment was conducted in 2021. In each field setting, five banana plants were randomly considered for the actual disease assessment. Typical disease symptoms on each infected sample plant were scrutinized and disease severity was scored on selected leaves (4 per sample plant) employing a 0–5 severity rating scale of Sigatoka streaks. Moreover, disease severity were recorded and in addition, infected samples were collected from the same sampling fields and brought to Melkassa Agricultural Research Center Plant Pathology Laboratory for further detection and identification of the disease. In addition, questioner was developed for further investigation about field history and agronomic practice used for production and disease management.

Disease incidence and severity rating

The incidence was calculated by counting visibly infected leaves or plants expressed as a percentage of the total number of leaves or plants sampled using the following equation.

DI%=Number of infected leaves or plants/Total number of leaves or plants assessed × 100

The disease severity scoring scale was 0-5 stage of black sigatoka disease symptom development as described by Fullerton and Olsen [6]. The scoring scale is described as; 0, no symptoms; 1, with 10% of the leaf area affected; 2, with 11-25% of the leaf area affected; 3 with 26-50% of the leaf area affected and 4 with 51-75% of the leaf area affected, 5 with 76% or more of the leaf area affected.

Isolation and Identification of causal agent

Isolation of banana sigatoka: A total of 144 leaf samples showing disease symptoms of Sigatoka were collected from banana fields in the major banana-growing areas of Ethiopia. Samples were taken to the laboratory in envelopes and were maintained at 5°C until processed to keep the sample from contamination. Leaf spots were ellipsoidal in shape with a yellow halo surrounding a dark outlined area of sunken, white, necrotic tissue in which the sporodochia were found. The sample was cut in to 2-3 mm size and plated on petri-dish having potato dextrose agar. Plates were incubated at 25°C for 2 days to induce conidial germination. Germinating conidia were transferred to new Petri plate having Potato Dextrose Agar (PDA) to purify.

Morphological identification and pathogenesity test: Fungal growth on PDA was determined after five days of incubation. Colony development was recorded as presence or absence of fungal growth from each isolated leaf tissue in each plate. Colony color and density were assessed by visual observation after seven days of growth starting from isolation date. Isolates were examined for their mycelia and conidial morphological characters by mounting on slides with the aid of a camera mounted microscope.

After the pathogen was characterized based on colony colour, conidia shape, mycelial structure and culture growth, disease free susceptible poyo variety was selected and multiplied by tissue culture laboratory of Melkassa Agricultural Research Centre. Isolated pathogen were purified and inoculated for the conformation of actual symptom observed during the survey.

Data analysis

Coordinate data were collected using handheld GPS and manual record were down loaded in to computer Microsoft excel program. Collected data were inserted and analysed by using IBM SPSS statistics 20.

RESULTS AND DISCUSSION

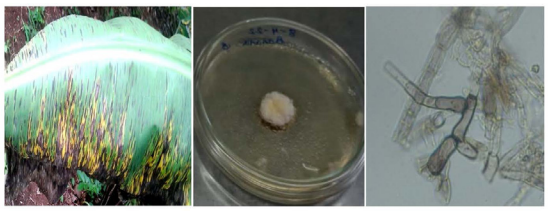
Banana black sigatoka: Symptom and causal agent

Black sigatoka, also known as black leaf streak disease or BLSD, is caused by the fungus *Mycosphaerella fijiensis*. Fusarium wilt and Black sigatoka diseases were reported in 2014 around Tepi Agricultural Research Centre which is potential area in banana production [7]. The disease affects leaves and thus the plant's ability to photosynthesize, resulting in bunches and fruits that weigh less than those from healthy plants. Severe infections of black sigatoka can also cause premature ripening of fruit. Black sigatoka *(Mycospherella fijiensis)* first causes small, light yellow spots or streaks on leaves which is severely observed in all banana producing areas of Ethiopia (Figures 1a-1c).

The symptoms run parallel to the veins as it is seen in Figure 1a and within a few days, the spots increase few centimetres in size and turn brown with light grey centres. These spots enlarge further and the tissue around the lesions turns yellow and dies. In cases of severe infection leaves may die within a few weeks. Because of the lack of leaf tissues, fruit maturity is hampered.

Distribution and relative importance of black sigatoka on banana

Banana is affected by different biotic and abiotic factors worldwide. Black sigatoka is the major leaf disease of banana and the pathogen described originally in the Sigatoka Valley of Fiji in 1963. Similarly, Black sigatoka diseases were reported in 2014 around Tepi in SNNPR [7]. The Survey result indicates that, the diseases were observed frequently in all assessed districts of Ethiopia during 2016 and 2021 with different magnitude. The highest black sigatoka severity was recorded 80 percent in Gura Farda district in Bench Maji Zone and the lowest severity was recorded 12 percent in Boset district of East Showa Zone. In Arbaminch Zuria and Samen Bench, the highest Sigatoka severity was 78% which shows the pathogen is economically important in potential banana producing areas of Ethiopia (Table 1). Similarly, the pathogen is known by its reduction in yield due to negative effects on the photosynthetic assimilation (50-100%) and thus on dry matter production, strongly affecting the bunch [8].



(a) (b) (b)

Figure 1: Symptoms of black sigatoka on banana at Bench Maji zone; (a) symptom of black sigatoka; (b) fungal growth and (c) conidia under microscope (40X).

Table 1: Distribution and Severity of black sigatoka on banana in major producing areas, 2016.

Zone	District	Altitude	Disease severity (%)
Bench Maji	Gura Ferda	1391	80
	Debub Bench	1517	73
	Semen Bench	1594	78
Jimma	Seka	1861	54
	Shabe	1698	60
	Sokorru	1905	62
East Showa	Boset	1300	12
	Merti	1216	36
Sidama	Dale	1763	60
	Aleta Wondo	1869	38
	Aleta Chuko	1818	44
Gamo Gofa	Arbamich Zuria	1161	78
	Merab Abaya	1207	44
	Darmalo	1157	50

Different study conducted resulted that, black sigatoka has been considered as the most damaging and costly disease of banana because its control accounts for 27% of total production costs [3]. It is one of the most serious biological threats to banana production for food security and export [3]. It has been estimated that the disease causes greater than 38% yield loss on plantain and even greater losses may occur on export bananas when control measures fail (Figure 2).

The cost of control can reach more than 25% of the production cost [9] and this cost has been steadily increasing over the years. In Tepi areas, black sigatoka diseases were reported serious trait of banana [7]. None of the banana production regions of Ethiopia is free of banana leaf streak disease called sigatoka. The result in Table 1 indicates that, the leaf areas of banana in Bench Maji in Bebeka farm (85% disease severity) was totally damaged by this pathogen indicating, high relative humidity were formed in the area due to over suffocation of the locality by forest. Both growth and yield are affected because of the reduction in the photosynthetic area [5]. Fruit loss varies from 30-50% depending on climatic conditions and the severity of the disease. Wherever *M. fijiensis* has been introduced, it has replaced *M. musicola* due to its higher spore production, shorter disease cycle and higher aggressiveness [10]. The pathogen variability was not identified in this study but black sigatoka were clearly confirmed in all assessed locations (Table 2).

Quick assessment was conducted during 2021 and the results from assessed fields showed 93.33% were infected by black sigatoka indicating the pathogen is highly increasing in the country (Table 2). Similarly, [11] among banana diseases black sigatoka is important in major banana producing areas of Ethiopia. The maximum disease incidence was recorded 100%, showing that the pathogen is economically very important on banana production. The highest black sigatoka severity, 75% was recorded in Kersa district of Jimma Zone and the lowest were recorded in the same district but in different kebele. In one field the symptom of black sigatoka were not seen and the field management was very good (Table 2).

As a result from this survey, in Ethiopia, this symptom was clearly observed where ever banana grows (Figure 1a). Disease development is directly influenced by climatic conditions, varietal susceptibility, and crop management. Geographical areas most affected by black sigatoka typically have favourable rainfall, relative humidity of more than 80%, and temperatures averaging between 23 and 28°C. The disease is most aggressive during rainy seasons because of the continuous presence of water films on leaves, thus favouring the release and infestation of spores. The same scenario was also observed in all assessed districts, having favourable environmental condition for both host and pathogen.

Morphological identification and pathogenesity test

Colonies on potato dextrose agar are slow growing, compact but with a velvety surface, prominently raised, grey to pale-buff or olive-green, black in reverse [12]. Similarly, the colonies of isolates showed very slow growth with grayish white, elevated centre and irregular edges on Potato Dextrose Agar (PDA). Conidia are formed singly at the apex of the conidiophore, later becoming lateral as the

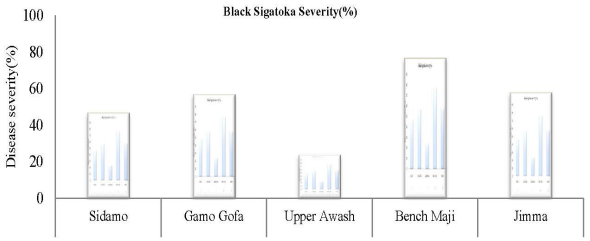


Figure 2: Black sigatoka mean severity across banana production, 2016.

Table 2: Distribution of banana diseases in Jimma and East Wollega Zones, 2021.

District	Kebele	Variety	Altitude	Disease Incidence (%)		Disease Severity(0-5)	
				BS	BW	BS	BW
Sokaru	Adami	Local	1844	80.0	100	25	1-2
Sokaru	Robi	Local	1912	100.0	0	30	0
Sokaru	Kerta	Kenya	1759	100.0	60	26	0-1
Kersa	Busa Bechena	Grand Naine	1749	100.0	0	75	0
Kersa	Busa	Grand Naine	1743	80.0	0	65	0
Kersa	Busa Bechena	Grand Naine	1742	40.0	0	40	0
Kersa	Busa Kusaye	Grand Naine	1741	0.0	0	0	0
Kersa	Busa Kusaye	Grand Naine	1740	100.0	0	25	0
Kersa	Merewa	Grand Naine	1793	100.0	0	25	0
Kersa	Ankaso	Grand Naine	1804	100.0	0	36	0
Goma	Kaso	Local	1567	100.0	0	38	0
Wayu Tuka	Boneya mulu	Grand Naine	1712	100.0	0	25	0
Wayu Tuka	Mena Kura	Grand Naine	1710	100.0	0	25	0
Bako Tibe	Bako 02	Grand Naine	1692	100.0	0	65	0
Beshoftu	Joy Tech	Grand Naine	1913	100.0	0	35	0

Note: BS (Black sigatoka); BW (bacterial wilt; for disease severity (0-2), show the maximum and minimum score.

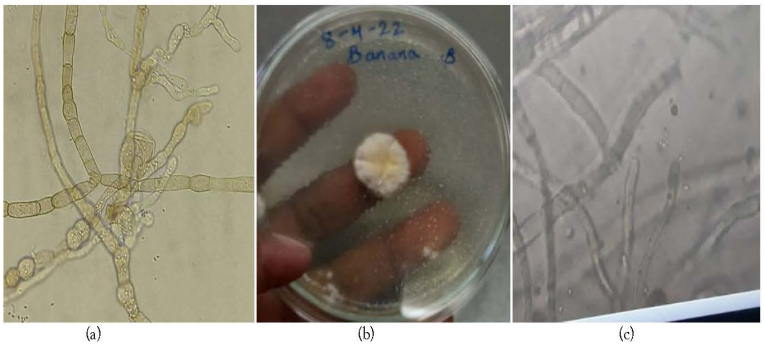


Figure 3: Colony color on PDA (a) 40X microscopic growth (b) mass of mycelia growth (c) 40X microscopic mycelial image.

conidiophore develops (Figures 3a-3c).

Up to four mature conidia may be attached to a single conidiophore. Straight or curved, obtuse at the apex, truncate or rounded at the base with a visible and slightly thickened hilum, 30-132 × 2.5-5 µm, the broadest point being near the base. Conidiophores are pale to medium olivaceous-brown, becoming slightly paler towards the tip.

The Pathogen is severely observed and identified during 2016 and 2021.

CONCLUSION

There are several important banana diseases present in different growing areas of the world. Black sigatoka and fusarium wilt of banana is highly affecting the production and quality of banana in

Ethiopia. Our survey confirms that in all assessed areas all banana plantations were infected by black sigatoka in different magnitude ranged from 12-80%.

Recent assessment result indicates that, 100 percent diseases incidence was recorded in Jimma and East Wollega Zones. In Kersa district of Busa Bechena kebele, 75% black sigatoka severity was recorded as a highest disease severity, 2021 growing season. During the 2016 growing season, the highest black sigatoka severity was recorded 80% in Gura Ferda district of Bench Maji Zone. This indicates that black sigatoka is important disease of banana which did not get attention in banana production system.

In conclusion, morphological and molecular characterization of Sigatoka disease of banana should be a basic research to be conducted. Disease epidemiology approach is requested to know specific month when the pathogen becomes aggressive should be identified and documented for banana producers.

RECOMMENDATION

This Study recommend that, eco-friendly and easily affordable managment practice should be employed to reduce the severity of black sigatoka. The adoption of micro propagate materials from *in vitro* tissue cultures is the best sanitation practice to prevent the dissemination of black sigatoka under field conditions. Therefore, basic studies on morphological identification should be conducted to characterize isolates. Screening of banana varieties should also be intensively conducted to identify tolerant/resistant banana genotype. Quantitative and qualitative survey is also important, to devise management options for early detect the pathogen. The involvement of both public and private sector on the production and dissemination of disease free and certified seedlings is important for improved productivity and quality of banana.

REFERENCES

1. FAOSTAT. Countries-Select All: Regions-World+(Total): Elements–Production Quantity: Items-Papayas. 2019.
2. Central Statistical Agency Agricultural sample survey, 2015-2020. The federal democratic republic of Ethiopia, Meher Season. 2020.
3. Marin DH, Romero RA, Guzman M, Sutton TB. Black Sigatoka: An increasing threat to banana cultivation. Plant disease. 2003; 87(3): 208-222.
4. Marín DH, Ching LD, Romero RA. Efecto de la Sigatoka negra sobre la productividad del platano. Corporacion Bananera Nacional – Informe Annual. 1991; 85-86.
5. Carlier J, Foure E, Gauhl F, Jones DR, Lepoivre P, Mourichon X, et al. Black Leaf Streak. Diseases of Banana, Abaca and Enset. 2000; 37-79.
6. Capó YA, Mora ML. Early evaluation of black leaf streak resistance by using mycelial suspensions of *Mycosphaerella fijiensis*. Mycosphaerella leaf spot diseases of bananas: present status and outlook. 2002;169.
7. Gabrekiristos E, Yesuf M, Ayana G. An optimized inoculation method of Fusarium wilt (*Fusarium oxysporum f. sp. Cubense*) causal agent of banana wilt disease in ethiopia. Greener J. Breed. Crop Sci. 2018; 6: 7-14.
8. Ramsey MD, Daniells JW, Anderson VJ. Effects of Sigatoka leaf spot (*Mycosphaerella musicola* Leach) on fruit yields, field ripening and greenlife of bananas in North Queensland. Scientia Horticulturae. 1990; 41(4): 305-313.
9. Stover RH, Simmonds NW. Bananas. Longman Scientific and Technical; 1987: 468.
10. Pérez L, Hernández A, Hernández L, Pérez M. Effect of trifloxystrobin and azoxystrobin on the control of black Sigatoka (*Mycosphaerella fijiensis* Morelet) on banana and plantain. Crop Prot. 2002; 21(1): 17-23.
11. Mulder JL, Holliday P. *Mycosphaerella fijiensis*. Descriptions of pathogenic fungi and bacteria, no. 413. Commonw. Mycol. Inst. Kew, England. 1974.
12. Gurmu T, Adugna G, Berecha G. Black Sigatoka leaf streaks of banana (*Musa* spp.) caused by *Mycosphaerella fijiensis* in Ethiopia. J Plant Dis Prot. 2017; 124(3): 245-253.