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Influence Of Crop Management And Soil On Plantain (*Musa* spp., AAB Group) Response To Black Sigatoka Infection In Southeastern Nigeria.

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Keywords: Survey – Plantain – Black sigatoka – Farming system – Soil fertility

Summary

An on-farm survey was carried out to assess the severity of black sigatoka caused by Mycosphaerella fijiensis *Morelet on plantain in southeastern Nigeria. Two different geomorphological zones (Meander belts and Coastal plain sands) were surveyed. Four locations were selected for each zone and two traditional farming systems (backyard and field) were studied in each location. Based on geomorphological zones, less black sigatoka infection was observed in the Meander belts than in the Coastal plain sands. On farming systems basis, plantain grown in the backyard gardens had lower disease severity than that planted in the field plots. This difference in black sigatoka severity is attributable to the higher soil fertility in the Meander belts than in the Coastal plain sands and in the backyards than in the fields.*

Résumé

Une enquête en milieu paysan a été menée pour évaluer la sévérité de la cercosporiose noire causée par Mycosphaerella fijiensis *Morelet sur le plantain dans le Sud-Est du Nigéria. Cette enquête a été réalisée dans deux zones géomorphologiques différentes (zone marécageuse et zone sableuse). Quatre sites étaient sélectionnés pour chaque zone et deux systèmes de culture traditionnelle (culture de case et culture en champ) étaient étudiés dans chaque site. Sur base de zones géomorphologiques, une plus faible infection de la cercosporiose noire était observée dans la zone marécageuse que dans celle sableuse. Se basant sur les systèmes de culture, le plantain cultivé autour des cases était moins infecté que celui cultivé en champ. Cette différence dans la sévérité de la cercosporiose noire est attribuable à la fertilité du sol plus élevée dans la zone marécageuse que dans celle sableuse et en culture de cases qu'en champs.*

Introduction

Plantain (*Musa* spp., AAB group) constitutes an important carbohydrate source in the diet of many people in the humid forest and mid-altitude agroecologies of the tropics. Its low labour requirement and relatively high energy output render plantain a suitable staple for areas where labour shortage is usually the main constraint to production. It is grown mainly by small-scale farmers and as such, is an integral component of most farming systems in West and Central Africa, where 50% of the world's plantain is produced (4,31).

In spite of its importance to local people, plantain has long been ignored by agricultural research in the region, since it had no major disease problems until the 1970s and was therefore regarded as a disease-free crop in Africa (31). Twenty years ago, however, the crop has been threatened by black sigatoka, an air-borne leaf spot disease caused by the fungus *Mycosphaerella fijiensis* Morelet. First recorded in Zambia in 1973 (23), the disease spread rapidly into Gabon (7), Cameroon (5), Congo (19) and Zaire (15,16). In 1986, it was detected in southeastern Nigeria, one of the main plantain producing regions of West Africa (32). Actually, black sigatoka is the most destructive leaf disease of plantain as it is spreading inexorably to all major lowland plantain growing regions quickly replacing yellow sigatoka (*Mycosphaerella musicola* Leach) as the dominant leaf spot (13). The disease does not only reduce yield, but also leads to premature ripening of fruits. Plantain yield losses of between 33 and 50% in the first cropping cycle have been reported (18,26).

In Nigeria, Rivers State ranks second in plantain production, after Bendel State (now Edo and Delta States) (12). In these regions, plantain is mostly cultivated in compound gardens and in outlying fields mixed with other food crops. In backyard gardens, plantain benefits from application of household refuse. This increases soil fertility, encourages luxuriant growth and all year round output. The homestead yield per hectare is estimated to be nearly four times that obtained in the field (20).

For these backyard gardens, there have been some investigations into the biological and economic factors affecting plantain production (20), but the effects on black sigatoka disease have not been studied. Since the production and movement of fungal inoculum (conidia and ascospores) depend on the ecological conditions (6,25), the aim of the present investigation was to evaluate the host response to black sigatoka of a common local plantain cv. "Agbagba" in different geomorphological zones under different farming systems, in relation to soil fertility.

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Material and methods

The survey was conducted in the two major geomorphological zones of Rivers State: Meander belts and Coastal plain sands. Four locations were selected for each geomorphological zone: Mbiama, Zarama, Venagoa and Imiringi in Meander belts and Port Harcourt, Eleme, Bori and Gokana in Coastal plain sands. The soils in the study areas are heterogeneous, as a result of the prevalent climatic conditions, the nature of parent materials, depth of the water table and flooding. Meander belt soils are moderately leached, quite permeable, loamy sand to sandy clay and moderately acidic. Coastal plain sand soils, however, are excessively leached, porous, sandy to sandy loam, poor in nutrients and highly acidic (1,9).

The most common cultivar is a False Horn plantain known locally as "Agbagba", with medium-sized pseudostem at flowering (29) and widespread in southeastern Nigeria (20). The survey was conducted during the dry (December-February) and the rainy (March-November) seasons of 1992. A summary of climatic data during the survey is shown in Table 1. The two major farming systems surveyed were the backyard gardens and field plantations. In each location two backyards and two fields with the same "Agbagba" cultivar were selected, both during the rainy and dry seasons. Then, 10 early flowering plants for each system were observed. Once plantain is flowering, the plant has reached the end of its vegetative development and no new leaves are formed. The investigation which was in the form of direct observation of the black sigatoka severity included also some background information such as age of plants, plant population, fertilization and land use pattern.

TABLE 1
Summary of climatic data of the selected locations in southeastern Nigeria during the dry (DS) and rainy (RS) seasons, 1992.

Location	Mean annual values					
	Rainfall (mm)		Temperature (°C)		Relative humidity (%)	
	DS	RS	DS	RS	DS	RS
Meander belts						
Mbiama	210	2552	26.6	24.5	78	88
Zarama	205	2513	26.2	23.9	78	87
Yenagoa	231	2559	25.4	23.3	79	88
Imiringi	260	2605	25.0	22.6	79	89
Mean	227	2557	25.8	23.6	79	88
Coastal plain sands						
Port Harcourt	206	2481	26.5	24.6	78	86
Eleme	175	2301	26.8	24.8	77	84
Bori	146	2234	27.2	25.6	76	85
Gokana	150	2240	27.3	24.8	77	85
Mean	169	2314	27.0	25.0	77	85

Source: Agricultural Development Programme (ADP)-extension offices.

The backyards differed from the fields by the regular application of household refuse and different types of mulch. The most common items in the refuse were cassava peels and kitchen wastes. Weeding was done only occasionally by the farmers because frequent application of refuse suppressed weeds. However, plantain was not planted in a specific arrangement and the plant density was higher than in field plantations.

At the beginning of rainy season (March 1992), soil samples were collected from both backyard and field in each location using a soil hand auger up to 20 cm depth, as the majority of plantain roots develop in the upper 15 cm of the soil (22,28). These samples were air-dried in the laboratory, crushed, passed through 0.5 and 2.0 mm sieves and analysed at the analytical service laboratory of the International Institute of Tropical Agricultura (IITA).

The Stover and Dickson (27) scale with the modifications introduced by Gauhl (8) and Pasberg-Gauhl (21) was used to determine the host-plant response to black sigatoka. This sevengrade non-linear scale has the following classes based on percentage of leaf area with symptoms: 0 = without symptoms, 1 = 1% and/or up to 10 spots with a dry center, 2 = 1% to 5%, 3 = 6% to 15%, 4 = 16% to 33%, 5 = 34% to 50% and 6 = 51% to 100%. The youngest leaf spotted (6,14) and the number of standing leaves given by the total leaves with less than 100% of necrotic leaf area were also recorded.

The yellowish depigmentation on the lower leaf surface was rated as the first symptom (stage 1) according to Fouré (6). The percentage of leaf area with symptoms for each plant was calculated by adding the maximum percentage of disease severity in the respective class and dividing this value by the number of standing leaves (18). The necrotic spot with a dry center is the final symptom of black sigatoka. The youngest leaf spotted was found positively correlated with the symptom evolution time at IITA, Onne Station (17). Therefore, the parameter youngest leaf spotted is a good indicator for the speed of disease development in the plant.

Calculated mean values obtained from each parameter were compared both between different locations and between different farming systems using Statistical Analysis System (24). Correlation coefficients between soil chemical properties and parameters for host response to black sigatoka were computed.

Results and discussion

No significant interactions were found between locations and farming systems for all the parameters studied both on soil fertility and on black sigatoka severity. Therefore, the statistical comparison carried out for each parameter was on the mean values of the two farming systems (10). The ANOVA's coefficients of variation ranged between 1% and 16%, which indicated a proper control of the experimental error throughout the survey.

1. Soil fertility

Soil analysis results presented in Table 2 showed significant differences in the amounts of nutrients between the two geomorphological zones (Meander belts and Coastal plain sands). According to Black's (2) and Brady's (3) scales, in Meander belt fields the soils are moderately acidic (pH 5.6-5.8) with high organic carbon (1.9-2.1%), medium total nitrogen (0.17-0.20%), low calcium (2.92-3.64 me./100 g), low magnesium (0.7-0.8 me./100 g) and moderate potassium (0.3-0.4 me./100 g) levels. In Coastal plain sand fields the soils are extremely acidic (pH 4.2-4.5) with moderate organic carbon (1.0-1.3%), moderately low total nitrogen (0.08-0.12%), very low calcium (0.44-0.86 me./100 g), very low magnesium (0.1-0.3 me./100 g) and very low potassium (0.1-0.2 me./100 g) values. This indicates that in Meander belt fields the amounts of soil nutrients are higher than in Coastal plain sand fields.

TABLE 2
Mean values of the selected soil chemical properties of both fields and backyards in different locations of Rivers States, southeastern Nigeria.

Location	pH (H2O)	Organic C (%)	Total N (%)	Exchangeable cations (me./100 g)		
				Ca	Mg	K
Meander belts						
Mbiama	6.3 b	2.97 b	0.25 b	6.09 b	1.47 b	0.69 b
Zarama	6.2 b	2.91 b	0.24 b	5.94 b	1.98 b	0.66 b
Yenagoa	6.3 b	2.81 b	0.23 b	5.64 b	1.32 b	0.62 b
Imiringi	6.4 b	2.87 b	0.23 b	5.76 b	1.35 b	0.64 b
Mean	6.3	2.89	0.24	5.86	1.53	0.65
Coastal plain sands						
Port Harcourt	5.2 a	2.23 a	0.15 a	3.57 a	0.71 a	0.49 a
Eleme	4.9 a	2.13 a	0.12 a	3.35 a	0.61 a	0.42 a
Bori	5.0 a	2.08 a	0.13 a	3.30 a	0.56 a	0.40 a
Gokana	5.0 a	2.18 a	0.15 a	3.43 a	0.65 a	0.46 a
Mean	5.0	2.16	0.14	3.41	0.63	0.44

Within columns, means followed by the same letter are not significantly different at the 0.05 probability level, according to Duncan's multiple range test.

In backyards the selected soil chemical properties were significantly higher than in fields (Table 3). In Meander belt homesteads the soils are neutral (pH 6.7-6.9) with very high organic carbon (3.7-3.8%), high total nitrogen (0.28-0.30%), moderate calcium (8.36-8.53 me./100 g), moderate magnesium (1.95-2.10 me./100 g) and high potassium (0.95-0.98 me./100 g) levels. In Coastal plain sand backyards, the soils are moderately acidic (pH 5.6-5.8) with high organic carbon (3.12-3.16%), medium total nitrogen (0.16-0.18%), moderate calcium (6.15-6.28 me./100 g), moderate magnesium (1.00-1.08 me./100 g) and high potassium (0.70-0.74 me./100 g) levels.

TABLE 3
Mean values of the selected soil chemical properties in plantain fields and backyard gardens of both Meander belt and Coastal plain sand locations, Rivers State, southeastern Nigeria.

Farming system	n*	pH (H_2O)	Organic C (%)	Total N (%)	Exchangeable cations (me./100 g)		
					Ca	Mg	K
Field	8	5.0	1.58	0.14	1.94	0.49	0.25
Backyard	8	6.3	3.46	0.23	7.33	1.52	0.84
LSD (0.05)		0.1	0.1	0.02	0.24	0.19	0.05

*n = Number of analysed plots.

These results indicate that the Meander belt soils are richer in nutrients than those of Coastal plain sands. Lal and Kang (11) reported that soils with relatively wet moisture regimes and higher clay contents have higher organic matter levels than sandy soils with relatively dry moisture regimes. On the other hand, soils in backyards are more fertile than in the fields, due to frequent application of household refuse and mulch which are sources of nutrients and act thus as a fertilizer. Organic matter is a key component of soil fertility, as a reservoir of nutrients, as a main source of cation exchange capacity and as major promoter of aggregate structural stability. Under intensive cultivation however, the soil degrades very rapidly, associated with a substantial decline in organic matter status (11).

TABLE 4
Effect of location on plantain cv. "Agbagba" response to black sigatoka (BS) under field and backyard conditions during both dry and rainy seasons of 1992 in Rivers State, southeastern Nigeria.

Location	Number of standing leaves	Youngest leaf spotted	% of leaf area with BS symptoms
Meander belts			
Mbiama	9.5 b	6.9 b	14.0 a
Zarama	9.3 b	6.9 b	14.5 a
Yenagoa	9.2 b	6.8 b	13.7 a
Imiringi	9.3 b	6.9 b	14.0 a
Mean	9.3	6.9	14.1
Coastal plain sands			
Port Harcourt	7.8 a	5.1 a	19.3 b
Eleme	7.7 a	4.9 a	19.3 b
Bori	7.6 a	4.8 a	20.1 b
Gokana	7.8 a	4.9 a	19.5 b
Mean	7.7	4.9	19.6

Within columns, means followed by the same letter are not significantly different at the 0.05 probability level, according to Duncan's multiple range test.

2. Host-plant response to black sigatoka

Effect of location

Two major geomorphological zones of Rivers State were found to be significantly different for all the parameters studied: Meander belts and Coastal plain sands (Table 4). However, within each zone there were no significant differences between locations. The black sigatoka severity of plantain was much lower in Meander belt locations than in those of Coastal plain sands.

The number of standing leaves indicates the effect of black sigatoka development on life time of the leaves. The "Agbagba" plantain cultivar in Meander belts zone had a significantly higher number of standing leaves than in Coastal plain sands zone. Thus, under good soil conditions plantain growth is better and leaf emission rate faster (29) and tend to be less affected by black sigatoka compared to plantain growing on poor soils.

With respect to the youngest leaf spotted, results (Table 4) show the same trend as for the number of standing leaves. There were significant differences between the two zones. In Meander belts the youngest leaf spotted was seven, whereas in Coastal plain sands the value was five. These results indicate that the "Agbagba" plantain cultivar in Meander belts showed this symptom stage two leaves older than in Coastal plain sands. Therefore, with a leaf emergence time of about one per week for plantain in general, the soil fertility (Table 2) of Meander belts slowed the symptom evolution by 2 weeks compared to that of Coastal plain sands.

Pronounced differences were also obtained between the two zones for the percentage of leaf area with symptoms (Table 4). While in Coastal plain sands the "Agbagba" plantain cultivar presented 19.3% to 20.1% of leaf area infected by *Mycosphaerella fijiensis*, in Meander belts however "Agbagba" lost only 13.7% to 14.5% of its leaf area. The slower spread of black sigatoka symptoms in Meander belts resulted in more functional leaf area compared to that of Coastal plain sands.

Effect of farming system

Significant differences were found between fields and backyards for all the parameters studied (Table 5). In backyards the plantain cv. "Agbagba" had a significantly higher number of standing leaves and showed necrotic spots two leaves older than in fields. Also, the plantain in backyards had 5.4% less leaf area affected by symptoms than that planted in fields.

TABLE 5
Effect of farming system on plantain cv. "Agbagba" response to black sigatoka (BS) during both dry and rainy seasons of 1992 in Rivers State, southeastern Nigeria.

Farming system system	n*	Number of standing leaves	Youngest leaf spotted	% of leaf area with BS symptoms
Field	160	7.6	5.0	19.5
Backyard	160	9.5	6.8	14.1
LSD (0.05)		0.1	0.2	1.2

*n = Number of observed plants

These results indicate that the speed of black sigatoka development was slower in backyards than in fields. Mobambo and Naku (15) observed in Zaire similar reactions of several banana and plantain cultivars being moderately susceptible in backyard gardens and highly susceptible in field plantations. Soil organic matter is considered as playing a major role in the host-plant performance of backyards compared to field-plots. Since household refuse and mulch regularly applied in backyards cover the soil, they induce simultaneously low temperature and therefore stimulate root ramification in plantain (30). The increased root ramification is correlated with a better plant development which is reflected in a higher nutrient uptake by the plantain and faster leaf emission.

Most of the backyard plantain was found in mixture with trees also grown in the compounds. With their deep roots, the trees might have recycled nutrients to the benefit of plantain which is shallow rooted. But, in most of the fields, plantain was interplanted with arable crops such as cassava and cocoyam, resulting in competition of soil nutrients. Whereas in most cases, plantain in backyards had been grown for about 25 years, in fields it had been cultivated for about 3 years only. Favourable conditions in backyard gardens are also related to high yield of plantain already reported by Nweke *et al.* (20).

Furthermore, black sigatoka severity was highly correlated with the selected soil chemical properties which are the most important for plantain growth (Table 6). There results suggest that climatic parameters (Table 1) were not a major factor influencing differences in disease severity between the different locations and/or farming systems. Rainfall, temperature and relative humidity were similar in the different geomorphological zones. Therefore, the difference in the host-plant response both between the two geomorphological zones and the two traditional farming systems was mainly due to the difference in soil fertility. The higher the soil fertility level, the lower the black sigatoka severity. On better soils this is expressed in a higher number of standing leaves, older leaves bearing dry spots and less leaf area with black sigatoka symptoms. Thus, proper management of soil organic matter and its maintenance at a favourable level for crop production is one of the key factors for reducing the black sigatoka severity.

Effect of season

There were significant differences between dry season and rainy season for the host-plant response to black sigatoka (Table 7). During the rainy season, plantain had one standing leaf more than in the dry season, indicating the higher frequency of leaf emergence during the rainy season. However, in the dry season, the youngest leaf spotted was one leaf older than in the rainy season. Also, only 15.0% of leaf area was affected by black sigatoka during the dry season, while in the rainy season 18.9% of leaf area was infected by the fungus.

TABLE 6
Correlations between soil fertility and host response to black sigatoka (BS) of the False Horn plantain cv. "Agbagba" under field and backyard conditions in Rivers State, southeastern Nigeria.

Soil chemical properties	Correlation coefficients (r): Number of standing leaves (n=8)		Youngest leaf spotted (n=8)		% of leaf area with BS symptoms (n=8)	
	Field	Backyard	Field	Backyard	Field	Backyard
pH	0.875**	0.867	0.888	0.893	-0.895	-0.863
%OC	0.979	0.974	0.973	0.969	-0.971	-0.975
%TN	0.861	0.858	0.835	0.856	-0.845	-0.851
Ca	0.864	0.870	0.886	0.866	-0.876	-0.874
Mg	0.871	0.873	0.875	0.886	-0.872	-0.873
K	0.907	0.971	0.876	0.896	-0.889	-0.972

** All r values are significant at the 0.01 probability level.

TABLE 7
Effect of season on plantain cv. "Agbagba" response to black sigatoka (BS) under field and backyard conditions in Rivers State, southeastern Nigeria, 1992.

Season	n*	Number of standing leaves	Youngest leaf spotted	% of leaf area with BS symptoms
Dry season	320	8.0	6.7	15.0
Rainy season	320	8.8	5.6	18.9
LSD (0.05)		0.2	0.1	0.5

*n = Number of observed plants.

These results indicate that despite the higher frequency of leaf emergence during the rainy season, the speed of black sigatoka development on these leaves was faster than in the dry season. Several authors have already found that black sigatoka disease is much more severe in the rainy season than in the dry season (6,17,25).

Conclusion

This survey undertaken in the main plantain growing areas of Rivers State has revealed the differential effects of geomorphological zones and farming systems on black sigatoka severity of a local False Horn plantain cultivar "Agbagba". In the Meander belts zone (Mbiama, Zarama, Yenagoa and Imiringi) the disease severity was less than in the Coastal plain sands (Port Harcourt, Eleme, Bori and Gokana). Within each zone however, no difference was observed between locations. The host-plant response is attributable to the difference in soil fertility between the two zones; Meander belt soils being more fertile than those of the Coastal plain sands.

Concerning the farming systems studied, soil fertility is the critical factor responsible for the difference between backyard gardens and field plantations. Because of high level of fertility due to frequent application of organic matter in the backyards, plantain was less infected by black sigatoka than that planted in the fields. Therefore, proper management of organic matter is essential for the sustainable productivity of plantain by minimizing the black sigatoka severity with low inputs. Since plantain is grown mainly by small-scale farmers in Africa, chemical fertilizers are not readily and economically available. Thus, the potential of traditional organic fertilizers such as compost, farmyard manure, crop residue mulches and planted fallow for building the soil organic matter status and nutrient supply need to be better exploited.

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