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Investigations into the Role of Weeds, Soil and Plant Debris in the Epidemiology of Foliar Fungal Diseases of Yam in Western Nigeria

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Abstract: The role of weeds, soil and plant debris in the epidemiology of foliar diseases of yam was investigated at Ibadan Western Nigeria in the lowland humid tropics. *Sclerotium rolfsii*, *Colletotrichum gloeosporioides*, *Colletotrichum graminicola*, *Pestalotia* sp., *Curvularia lunata*, *Curvularia eragrostidis*, *Drechslera* sp. and *Rhizoctonia solani*, fungi that can be pathogenic on yam (*Dioscorea alata*) were isolated from weeds in the vicinity of the yam plots. Plant debris found with the yam plots also contained *Sclerotium rolfsii*, *Colletotrichum gloeosporioides* and *Rhizoctonia solani*. High inoculum densities of $4.61\pm0.36x10^5$ cfu g^{-1} of *S. rolfsii*, $3.22\pm0.14x10^5$ cfu g^{-1} of *R. solani* and $4.32\pm0.39x10^5$ cfu g^{-1} of *C. gloeosporioides* were recorded in soil obtained from yam fields that were manually weeded 3 times during the experimental period. Soil samples in yam plots that were manually weeded 3 times and those yam plots prepared by clearing and burning the debris *in situ*, had varying inoculum densities of these pathogens. On yam fields with burnt debris, the incidence of Sclerotium leaf blight, Rhizoctonia leaf blight, Curvularia leaf spot and Pestalotia leaf spot were lower than those recorded after other treatments. In fields with burnt debris, the incidence of anthracnose from *C. gloeosporioides* was 26.9%, while in yam fields that were weed free and those that were manually weeded 3 times, the incidence of the anthracnose disease was 45.3 and 65.7%, respectively.

Key words: Weeds, plant debris, soil, foliar diseases, *Dioscorea* sp., epidemiology, pathogen

INTRODUCTION

Yam (*Dioscorea* sp.) is one of the staple foods in the tropics and other parts of the world[1]. West Africa produces about 90-95% of the world yam production of which 71% is grown in Nigeria[2]. As of 1997, the annual production of yam in Nigeria was estimated at 23.9 million tons[3]. *Dioscorea* sp. are grown mainly in the rainy season, which makes the crop susceptible to diseases, weeds and pest attack. Foliar diseases of yam have been reported as one of the major constraints of production in Nigeria[4,5] and yam anthracnose caused by *Colletotrichum gloeosporioides* has been reported to cause losses in excess of 90%[6]. Amusa *et al.*[7] reported the occurrence of 11 different foliar pathogens of yam in south-western Nigeria. The role of some of these pathogens either alone or in combination with others has been reported[6-9].

Weeds have been reported to cause a reduction of about 73% yield in yam[10]. Akobundu[11] showed that these losses were both direct (reductions in growth, stand and tuber dry weight) and indirect (i.e. damage caused by other pests that use weeds as alternate hosts). However, in Nigeria there is little or no information on the roles played by weeds, soil and plant debris in the foliar disease development in yam. This study was undertaken to investigate the role played by weeds, soil and plant debris in the epidemiology of foliar diseases of yam at Ibadan in the lowland humid tropics.

MATERIALS AND METHODS

Field plots were located in the yam experimental fields of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, which lies within the lowland humid rain-forest zone. The mean annual rainfall of 1150-1500 mm occurs mainly between April and October with the major peak in June. Higher relative humidity values (80-95%) are recorded during the rainy season than the dry season (20-50%). The field used for the experiment was prepared by bush clearing using cutlasses followed by heap moulding using hoes typical of local yam producers in south-western Nigeria. The yam minisetts used was *D. alata*, which is mostly cultivated in south-western Nigeria and was planted in mid March 1999 and 2000. Three field treatment

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were used, an initial treatment with a pre-emergence herbicide (Atrazine, 2.5 kg ai ha^{-1}) and repeated manually hoeing, manually weeding three times during the period of the experiment and the use of yam plots prepared by clearing and burning the debris in situ. Each yam plot was 10x8 m and each treatment included three rows replicated three times. Sixty-three plants were planted per plot, with each yam set planted 1 within and between rows; 1×1 m of the yam plot was used as border rows. The incidence and severity of foliar diseases were determined in each of the experimental fields[3,12] .

Weed plants within a 5 m radius around the experimental plots showing leaf spot and leaf blight disease symptoms were collected. The infected portions were excised, cut into 2 mm pieces and surface sterilized with 0.524% (w/v) sodium hypochlorite for 30 sec and rinsed in 4 successive changes of sterile water. Samples were plated on acidified potato dextrose agar (APDA) acidified with 0.2 N HCl and incubated for 6 days at 26°C under a 12 h photoperiod. The pathogens were identified by microscopic examination[13] and also by comparison with standard isolates obtained from the yam pathology laboratory IITA, Ibadan, Nigeria, which had been previously identified at CABI Biosciences Egham, UK.

One gram of soil samples obtained from each of the treatments were placed in 9 mL of sterile distilled water vigorously shaken on a whirlimixer for 10 min and serially diluted to 10^{-6} g after which 1 mL of the 10^{-4} to 10^{-6} suspensions was plated on APDA. The plates were incubated for 6 days at 26°C and pathogens identified by microscopic examination by Barnet and Hunter[13,14]. Plate counts (colony forming units-cfus) were used to determine the inoculum load or population of the pathogens in the soil. The experiment was conducted in the 1999 and 2000 planting season.

Pathogenicity of the isolates: Eight-week-old seedlings of the tropical *Dioscorea alata* (TDa) grown in non-sterile soil contained in 15 cm-diameter plastic pots were inoculated by spraying to run off with a mycelial suspension at an inoculum density of $2.4x10^6$ colony forming units (cfu) of each of the isolates on the leaflets using a master hand sprayer. The mycelial suspension was obtained by culturing the fungal isolates in potato dextrose broth in 100 mL conical flasks. The mycelial mats were harvested and blended in a Waring blender and diluted to a desired concentration. Plate counts were used to determine the inoculum load of each isolate. A drop of Tween 80 L^{-1}. of inoculum was added to the mycelia suspension as a wetting agent. The control plants were sprayed with sterile distilled water. Six potted yam plants/per treatment were replicated three times in a complete randomised block design. The isolated fungi which includes *Sclerotium rolfsii, Colletotrichum gloeosporioides*, *C. graminicola*, *Pestalotia* sp., *Curvularia lunata*, *C. eragrostidis*, *Drechslera* sp., *Pestalotia* sp., *Fusarium* sp. and *Rhizoctonia solani*, were tested, with each isolate considered as a single treatment. The inoculated and control plants were incubated for 48 h in transparent polyethylene bags in a moist chamber at 80-85% relative humidity and 22-25°C. The plants were then placed on the greenhouse bench and observed for wilting, leaf spot and blight disease symptoms. The pathogens were later isolated from yam plants showing symptoms of infection and compared with the initial isolates.

RESULTS

Ten fungi potentially pathogenic to yam were isolated from fourteen weed species were found to harbor (Table 1). The most prevalent fungi were *Colletotrichum gloeosporioides*, *C. graminicola, Curvularia* sp. and *S. rolfsii*, *S. rolfsii*, *Curvularia* sp. and *Rhizoctonia solani* were isolated from yam debris. The soil assay contained *S. rolfsii* at the highest inoculum loads of $4.61\pm0.36x10^5$ cfu g^{-1} of soil in yam fields weeded 3 times. In comparison, inoculum load of $0.03\pm0.002x10^3$ cfu g^{-1} of soil and $4.46\pm0.42x10^5$ cfu g^{-1} of *S. rolfsii* were found in yam fields with burnt debris and weed free plots, respectively (Table 3). Inoculum loads of *R. solani* and *C. gloeosporioides* in yam plots weeded 3 times were $3.2\pm0.1x10^5$ cfu g^{-1} of soil and $4.32\pm0.39x10^5$ cfu g^{-1} of soil, respectively. In yam plots with burnt debris the inoculum densities of *R. solani* and *C. gloeosporioides* were $0.08\pm0.0041x10^3$ soils and $4.46\pm0.421x10^5$ cfu g^{-1} and $0.15\pm0.003x10^3$ soil and $3.62\pm0.25x10^5$ cfu g^{-1} of soil in weed free plots soil. The inoculum densities of *Curvularia* sp. and *Pestalotia* sp. in soil obtained from yam plots are shown in Table 3.

In the pathogenicity test *S. rolfsii* induced circular leaf spots of various sizes that formed in concentric rings on the test plants, while *Pestalotia* sp. caused dark brownish spots with a reddish border. *R. solani* induced stem blackening and stem tip die back on mature plants, black spots on juvenile leaves and brown water-soaked leaf spots on mature leaves. *C. gloeosporioides* produced small brown spots which eventually enlarged and spread, ultimately affecting a large proportion of the foliage, the petioles and the stem by *Curvularia* sp. induced circular leaf spots.

The field disease score, for the incidence of anthracnose induced by *C. gloeosporioides* was 26.9%, in fields with burnt debris, while in yam fields that were

Table 1: Survey of weeds and the associated fungal pathogens in yam (D. alata) plots

	Fungal pathogens/frequency of occurrence									
Weed plants	*Colletotrichum graminicola*	*Fusarium* sp.	*Pestalotia* sp.	*Curvularia* sp.	*Sclerotium rolfsii*	*Curvularia lunata*	*Colletotrichum gloeosporioides*	*Curvularia eragrostidis*	*Rhizotonia solani*	*Dreschlera* sp.
Acalypha ciliata							89			
Acanthospermum hispidium								26		64
Centrocema pubescens							62			
Chromoleana odoranta							100			
Commelina benghalensis		20				16				
Commelina erecta					100					
Cynodon dactylon	82			18						
Ephorbia heterophylla					60					
Ipomea triloba					91					
Ipomea involucrata				6	94					
Ipomea sp.				100						
Mucuna pruriences	20						40			
Panicum maximum	65			35						
Syndrella nodiflora							100			

Table 2: The incidence (%) and severity of foliar diseases of yam (*D. alata*) in three experimental

	Anthracnose		Sclerotium leaf spot		Rhizoctonia blight		Curvularia leaf spot		Pestalotia leaf spot	
Treatments	Incidence	severity	Incidence	severity	Incidence	severity	Incidence	severity	Incidence	severity
Weed free	45.26b	3.48ab	21.85b	3.28ab	12.14b	2.23ab	4.52ab	2.14a	9.18b	2.12a
Weeded three times	65.72a	3.75a	31.18a	3.56a	16.15a	2.32a	5.67a	2.16a	12.17a	2.08a
Burnt debris	26.85c	2.24c	12.32c	2.21c	8.17c	2.18ab	3.18c	2.13a	8.05c	2.06a

Means followed by the same letters are not significantly different at p=0.05%

Table 3: The inoculum density of fungal pathogens found associated with foliar diseases of yam in yam cultivated soil

Pathogen	Yam fields with burnt debris Inoculum cfus g^{-1}	Yam fields (Weeded three times) of soil	Yam fields (Weed free)
Colletotrichum gloeosporioides	0.08±0.004* X10^3	4.32± 0.39 X10^3	3.46±0.25 X10^3
Sclerotium rolfsii	0.03±0.002 X10^3	4.61±0.36 X10^3	4.46± 0.42 X10^3
Rhizoctonia solani	0.15±0.003 X10^3	3.22±0.14 X10^3	3.62± 0.38 X10^3
Curvularia lunata	0.12±0.002 X10^3	6.41±0.42 X10^4	6.52± 0.46 X10^4
Pestalotia sp.	0.08±0.001 X10^3	1.25±0.08 X10^3	1.15± 0.07 X10^3
Curvularia eragrostidis	0.10±0.003 X10^3	4.89±0.46 X10^4	3.76± 0.34 X10^4

• Standard deviation

weed free and those that were manually weeded 3 times, the incidence of anthracnose was 45.3 and 65.7%, respectively. In yam fields with burnt debris, the incidence of *Sclerotium* leaf blight, *Rhizoctonia* leaf blight, Curvularia leaf spot and *Pestalotia* leaf spot were lower to these obtained in other treatments (Table 2). The cultural and morphological features of the re-isolated fungi were the same as for the initial inoculum and control plants showed no symptoms of infection.

DISCUSSION

Most of the fungi isolated from the weeds plants were potentially pathogenic on yam. This supports the earlier report by Emua and Fajola[15] on leaf spot- inducing fungi on yam. Amusa *et al.*[7] also reported the occurrence of *C. gloeosprioides*, *C. graminicola*, *S. rolfsii*, *Pestalotia* sp., *Botryodiplodia theobromae*, *Curvularia pallescens*, *C. eragrostidis*, *R. solani* and *F. oxysporum* in leaf spot diseases of cultivated yam in western Nigeria. *Colletrotrichum gloeosporioides*, the causal agent of yam anthracnose, has been reported to cause losses in excess of 90%[6]. This pathogen was also found in this study associated with *Commelina beghlensis*, *Chromoleana odoronta*, *Acalypha ciliata*, *Centrosema pubescens* and *Acanthro spermium* inspidium, all were weeds commonly encountered in yam fields in western Nigeria[10]. *Chromoleana odoronta*, *Syndrella nodflora* and *Ipomoea* sp. have previously been associated with *C. gloeosporioides* and *S. rolfsii* in yam fields[5]. *Colletotrichum gloeosporioides* is probably the most ubiquitous of all *Colletotrichum* sp. and has been recorded from a wide range of hosts[10]. Although wet conditions and susceptibility of host tissue at the time of infection are necessary for disease development, the ability of the fungus to survive in hosts when the environmental conditions are unfavorable enables the pathogen to overwinter between the susceptible stages of the cropping cycle[16].

Curvularia lunata and *Collectotricum graminicola* were isolated from the grasses *Panicum maximum* and *Cynodon dactylon*. These fungi are known to produce phyto-toxic metabolite[5] and induce necrotic lesions on yam plants. Amusa *et al.*[7] reported that both *Collectotricum graminicola* and *Curvularia lunata* are likely to be transient organism on yam and that they probably overwinter in necrotic lesions on the crop induced by other pathogens.

The results of this study showed that in yam fields where debris was burnt in situ inoculum densities were lower compared to those of other treatments. This supports the view that some pathogens of tuber root crops survive in plant debris[17]. The most prevalent pathogen both the weeds and debris was *S. rolfsii*. This species has been reported to induce concentric leaf spots on yams and is regarded as one of the most important pathogens of yam causing serious damage to leaves and stems[9] and can also induce rots in tubers[2,18]. When infected tubers are left on the surface of a field, numerous

sclerotia are produced and these may act as inoculum for subsequent infection in that field. This could explain why diseases caused by this pathogen are usually endemic in yam fields. The role of *R. solani* as a pathogen of yam has also been reported by Green *et al.*[9]. The fungus is the causal agent of yam leaf blight and has been described as a serious pathogen of *D. Rotundata*[6]. *Rhizoctonia solani* has been reported to survive in the absence of the host on weeds in Nigeria[20,21] and a significant proportion of the yield losses in yam[2,20] attributed to weeds might have resulted from infection of plants by pathogens being harboured by weeds.

The occurrence of yam pathogens in soils obtained from yam plots indicates that soil is a potential source of primary inoculum[13]. This may cause the production of patches of infection found scattered through fields in the early stages of the disease epidemics. The soilborne nature of *R. solani* has been reported by Onesirosan[21] and Oben *et al.*[22], while both *S. rolfsii* and *Colletotrichum* sp. have also been reportedly isolated from soil[9].

Sclerotium rolfsii and *R. solani* produce sclerotia and the germination of these are stimulated when they are re-moistened after a period of low humidity[23]. These fungi can therefore probably survive from one season to another by means of sclerotia or by continued growth. *Sclerotia* can easily be moved across the surface of the soil by rain splash and flooding.

It could be inferred from this study that the severity of some of the foliar diseases of yam could be reduced considerably if the sites on which yams are grown are sampled for the presence of some of the pathogens and debris harbouring the pathogens. Such debris should then be burnt before planting. In south-western Nigeria burning of plant debris especially after bush clearing as a means of weed control has been an age long practice. Burning of plant debris known to harbor pathogens has been reported to reduce inoculum potentials of *S. rolfsii* and *R. solani* in cassava and yam plantation[8,24] Early ploughing has been reported to reduce *Slerotium rolfsii* disease of cassava thorough disking, which exposes the sclerotia to early germination and exhaustion[24]. As weeds found within and around the yam plots are now known to harbor potential yam pathogens, keeping yam plots weed free will reduce the rate of infection by pathogens harbored by these weeds. This will also reduce the soil inoculum as many of these pathogens gain access to the soil through the debris of weed plants and the crops.

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