Panama Disease on East African Highland Bananas

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ABSTRACT

In 1992, the incidence and severity of fusarium wilt was assessed in high altitude banana-producing areas (≥900 meters above sea level, masl) in East Africa. The disease was most prevalent on recently introduced (exotic) cultivars. On highland AAA cultivars, fusarium wilt was observed only in Uganda. Damage was uncommon and did not occur below 1400 masl. The causal agent, *Fusarium oxysporum* f. sp. *cubense* (FOC), was recovered with difficulty from affected highland bananas. Despite the paucity of compatibility observed between VCG 0124-0125 testers and highland isolates, this recently introduced FOC population is clearly involved in outbreaks on highland cultivars. Although significant damage will continue to occur on susceptible exotic cultivars in East Africa, it is difficult to forecast what future damage will occur on highland clones.

La maladie de Panama sur les bananiers locaux d'Afrique de l'Est.

RÉSUMÉ

L'étendue et la gravité de la maladie de Panama ont été évaluées en 1992 dans les zones de production de bananes de haute altitude (≥ 900 m) en Afrique de l'Est. La maladie est plus répandue chez les cultivars récemment introduits.
Sur les cultivars locaux des montagnes, la maladie n'a été observée qu'en Ouganda.
Les dégâts sont rares et n'apparaissent pas au dessus de 1400 m.
L'agent pathogène, *Fusarium oxysporum* f. sp. *cubense* (FOC) a été difficilement reconnu sur les bananiers locaux atteints.
Malgré le manque de compatibilité végétative entre les testeurs et les isolats locaux d'altitude, il est évident que cette population de FOC récemment introduite est impliquée dans le développement des pathogènes sur ces cultivars d'altitude.
Bien que des dégâts significatifs continuent à atteindre les cultivars sensibles exotiques en Afrique de l'Est, les dégâts sur les clones locaux ne sont pas faciles à prévoir.

La enfermedad de Panamá en los bananos locales de Africa Oriental.

RESUMEN

La extensión y la gravedad de la enfermedad de Panamá fueron evaluados en 1992 en la zonas de producción de bananas de gran altitud (≥ 900 m) en Africa Oriental.
La enfermedad está más extendida en las variedades recientemente introducidas.
En las variedades locales de las montañas, la enfermedad sólo se observó en Uganda.
Los daños son escasos y no se producen por encima de los 1400 metros.
El agente patógeno, *Fusarium oxysporum* f. sp. *cubense* (FOC) ha sido reconocido difícilmente en los bananos locales afectados. A pesar de la falta de compatibilidad vegetativa entre los comprobadores y los aislados locales de altitud, es obvio que esta población de FOC recientemente introducida está envuelta en el desarrollo de los patógenos de las variedades de altura.
Aunque daños significativos siguen alcanzando a las variedades sensibles exóticas en Africa Oriental, los daños en los clones locales no son fáciles de prever.

KEYWORDS

Fusarium oxysporum, *Musa*, East Africa, land varieties, introduced varieties, damage.

MOTS CLÉS

Fusarium oxysporum, *Musa*, Afrique orientale, variété indigène, variété introduite, dégât.

PALABRAS CLAVES

Fusarium oxysporum, *Musa*, Africa oriental, variedades indigenas, variedades naturalizadas, daños.

introduction

Highland cultivars of banana are a unique and significant food source in East Africa (Sebasigari, 1987). All highland clones are triploid hybrids of *Musa acuminata* (AAA) which, since they are known nowhere else in the world, are presumed to have evolved in the region. Simmonds (1962) considered that precursors of highland cultivars were of Malay-Indonesian origin and probably introduced to the East African highlands via Madagascar several hundreds of years ago.

Until about 1940, highland clones were virtually the only bananas grown in the western Rift valley region. At that time, exotic cultivars began being introduced into East Africa. Unlike the highland cultivars, the new clones had diverse genotypes (*i.e.* AB, AAA, AAB, and ABB) and were tolerant to drought and poor soils, or resistant to nematodes (*Radopholus similis*, *Pratylenchus coffeae* and *P. goodeyi*) and the banana weevil (*Cosmopolites sordidus*) (Sebasigari and Stover, 1988). Because of these latter attributes, exotic cultivars are now widely used in East Africa, especially in low productivity areas.

Shortly after their introduction into East Africa, some exotic clones began succumbing to fusarium wilt, caused by *Fusarium oxysporum* f. sp. *cubense* (FOC) (see Ploetz *et al.*, 1990 for recent history). Initial outbreaks in the early 1950s, which were centered in an area shared by Kenya, Tanzania, and Uganda, have now spread throughout much of the region. In general, damage has been restricted to exotic clones.

In 1990, fusarium wilt was reported on highland cultivars in Uganda and Zaire (Ploetz *et al.*, 1990). At the time, only very minor damage was recognized (*e.g.* a single mat in Zaire). However, a recent appraisal suggested that these outbreaks more severe than initially stated, at least in Uganda (Rubihaiyo and Gold, 1993). Since producers often attributed fusarium wilt damage on highland clones to banana weevils, it is likely that the actual extent of the disease had been underestimated in past assessments.

To determine the current status of fusarium wilt on highland clones, a survey of important highland-production areas was conducted in August, 1992. The objectives of the survey included determining: 1) what highland cultivars were affected, 2) whether outbreaks on exotic and highland clones were related, and 3) if there was potential for greater damage on highland clones. This paper elaborates information published in a preliminary report (Tushemereirwe and Ploetz, 1993), and is the first detailed description of fusarium wilt on highland bananas.

materials and methods

disease survey

The following areas were included in the survey: Kabale and Bushenyi Districts in Uganda (Figure 1), Cibitoke and Rotuna Provinces of Burundi, and Kibungo Prefecture in Rwanda. Although the survey focussed primarily on highland clones, fusarium wilt was also examined on exotic cultivars. At survey sites, the altitude was determined with a Thommen TS TX altimeter (Revue Thommen AG, Hauptrasse, 4437 Waldenburg, Switzerland), and producers or caretakers were interviewed to ascertain production and disease histories for each site and area.

isolate collection

Tissue samples were collected from a total of 41 symptomatic plants (Table 1). Thirty-seven of the samples were collected during the survey, 35 of which were taken directly back to Florida by Ploetz. Two remaining samples from Rwanda were later forwarded to Ploetz by Jones along with four samples from Uganda which were collected by Tushemereirwe. To isolate FOC, small blocks of symptomatic tissue, about 5 cm^2, were harvested from pseudostems or, in the case of some highland plants, rhizomes. Tissues were allowed to air-dry and stored in plastic bags for transit to Florida.

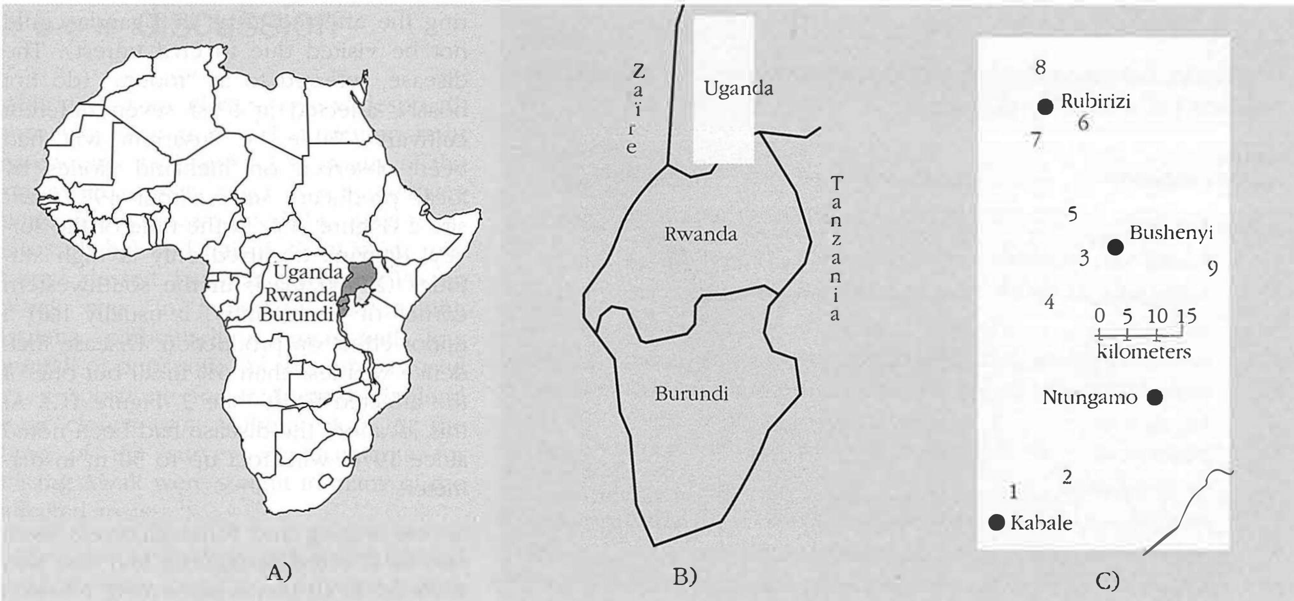

Figure 1
A) Location of Burundi, Rwanda, and Uganda on the continent of Africa;
B) in the dashed rectangle, the location of the highland area in Uganda in which fusarium wilt caused damage to highland AAA cultivars;
C) detail of circumscribed area in B) with the relative locations of nine sample sites; site numbers correspond to those listed in Table 1.

Due to damage to the PLOETZ laboratory during hurricane Andrew, tissue samples could not be processed for FOC recovery until about one month after the survey. Sample pieces were surface-disinfested in 70% ethanol (10 sec) followed by 10% household bleach (2 min), and subsequently submerged in molten 1.5% Bacto-Agar (45°C) amended with 100 mg/l streptomycin sulfate, 25 mg/l rifamycin, and 50 mg/l Danitol 2HEC (a commercial miticide produced by Chevron Agrichemical). After solidification, plates were inverted and incubated on a laboratory bench. Colonies of *Fusarium* spp. that developed were single-spored using a microspatula and compound microscope, and cultured on banana-leaf agar for identification. Isolates identified as *Fusarium oxysporum* (NELSON *et al.*, 1983) were used in vegetative compatibility tests.

vegetative compatibility tests

Vegetative compatibility was used to assess relationships among *F. oxysporum* isolates. Previously described procedures for generating, phenotyping, and using nitrate-nonutilizing (*nit*) auxotrophic mutants in genetic complementation tests were utilized (CORRELL *et al.*, 1987). Reciprocal NitM and *nit*1 comparisons were conducted between all isolates in the East African set and testers for vegetative compatibility groups (VCGs) in the world FOC collection in the PLOETZ laboratory (PLOETZ, 1995) (Tables 1 and 2). Tests were also conducted to assess whether isolates were self-compatible (CORRELL *et al.*, 1987). All tests were conducted at least twice.

results

Exotic banana cultivars were less common than highland clones in the surveyed areas. Of the exotics, Pisang Awak ABB, known locally as Kayinja, was the most common and most severely affected. Gros Michel AAA and Sukari Ndizi AB (which is known as Kamaramasenge in Rwanda), were also damaged, but were far less common than Pisang Awak. Silk AAB, Bluggoe ABB and Ney Poovan AB (Kisubi), all previously reported to be affected by fusarium wilt in East Africa (SEBASIGARI and STOVER, 1988), were not observed outside cultivar collections and test sites during the mission and were thus presumed to be uncommon in the survey areas.

Fusarium wilt was observed on highland clones only in Uganda (Figure 1) (unfortunately, highland sites in Rwanda borde-

Table 1
Descriptions of tissue samples collected during survey of East African highland banana-producing areas.

Sample no.[a]	Cultivar[b]	Location[c]	Altitude[d]	Ident.[e]
UGANDA				
1	Kayinja ABB	Kawanda ARS, Mpigi District	1 210	0125
2	Sukari Ndizi AB	Kawanda ARS, Mpigi District	1 210	0124
3	*Nakyetengu*	(1) Bukinda, Kabale District	1 860	si
4	*unknown highland*	(1) Bukinda, Kabale District	1 860	nonFO
5	Kayinja ABB	(1) Bukinda, Kabale District	1 860	nonFO
6	Kayinja ABB	(1) Bukinda, Kabale District	1 860	nc
7	*Enyaburuni* (or *Nakabululu*)	(1) Bukinda, Kabale District	1 860	nonFO
8	*Mbwazirume*	(2) Muhanga, Kabale District	1 720	nonFO
9	*Muburansika*	(2) Muhanga, Kabale District	1 720	nonFO
10	*Kibuzi*	(2) Muhanga, Kabale District	1 720	0124
11	Gros Michel AAA	(2) Muhanga, Kabale District	1 720	nonFO
12	*Enyeru*	(3) Rushoroza, Bushenyi District	1 650	si
13	*Enyeru*	(3) Rushoroza, Bushenyi District	1 650	0124
14	*Enyeru*	(3) Rushoroza, Bushenyi District	1 650	nonFO
15	Gros Michel AAA	(4) Butagasi, Bushenyi District	1 530	nc
16	*Muziranyama*	(4) Butagasi, Bushenyi District	1 530	nc
17	*Enyeru*	(4) Butagasi, Bushenyi District	1 530	nc
18	*Enzirabahima*	(4) Butagasi, Bushenyi District	1 530	nonFO
19	*Enzirabahima*	(4) Butagasi, Bushenyi District	1 530	si
20	*Enyeru*	(5) Ishaka, Bushenyi District	1 600	nc
21	*Mbwazirume*	(5) Ishaka, Bushenyi District	1 600	0124
22	*Mbwazirume*	(6) Rurama, Bushenyi District	1 400	nc
23	*Enyeru*	(6) Rurama, Bushenyi District	1 400	nc
24	*Mbwazirume*	(6) Rurama, Bushenyi District	1 400	nc
25	Sukari Ndizi AB	(7) Ryemondo, Bushenyi District	1 410	0124
26	*Enyeru*	(7) Ryemondo, Bushenyi District	1 410	nonFO
27	Sukari Ndizi AB	(8) Kichwamba, Bushenyi District	1 207	nc
28	Kayinja ABB	(8) Kichwamba, Bushenyi District	1 207	nc
39	*Enzirabahima*	(9) Rubale, Bushenyi District	1 500	nonFO
40	*Entarangaza*	(9) Rubale, Bushenyi District	1 500	nonFO
41	Gonja AAB	(9) Rubale, Bushenyi District	1 500	nc
42	*Enyeru*	(9) Rubale, Bushenyi District	1 500	nc
BURUNDI				
29	Kayinja ABB	Mugina, Cibitoke Province	1 050	0124
30	Kayinja ABB	Cibitoke, IRAZ/INIBAP Trial Site	900	0124
31	Niyarma Yik AA	Cibitoke, IRAZ/INIBAP Trial Site	900	0124
32	Pelipita ABB	Cibitoke, IRAZ/INIBAP Trial Site	900	0124
33	Kayinja ABB	Cibitoke, IRAZ/INIBAP Trial Site	900	0124
35	Pome AAB	Murama Hill, Rotuna Province	1 250	0124-5
36	Kayinja ABB	Murama Hill, Rotuna Province	1 250	0124-5

ring the affected areas in Uganda could not be visited due to civil unrest). The disease, referred to as "todura" (do not boast), affected at least seven different cultivars (Table 1). Fusarium wilt had been observed on highland clones by local producers since about 1972 near site 2 (Figure 1C). At the time of the survey, damage occurred only at high altitudes (≥1400 masl) in the southwestern corner of the country; it usually had a minor effect on production. Disease incidence was less than 5% in all but one of the affected fields (site 2, Figure 1C). At this location, the disease had been noted since 1976, with foci up to 50 m in diameter.

Severe wilting and foliar chlorosis were rare in affected plants, but leaf size was reduced; heart leaves often died, whereas other leaves in the canopy frequently developed dry margins 1-2 cm wide. Pseudostem girth and bunch size were reduced and fingers did not completely fill. Occasionally, leaf petioles buckled and leaf bases split. Although extensive discoloration of the host vascular system could develop in the rhizome, only individual vascular strands were affected; discoloration rarely extended into the pseudostem.

Since fusarium wilt on highland clones was noted only in Uganda, most of the tissue samples analyzed came from this country (78%, 32 of 41 total); far fewer samples were collected in Burundi (17%, 7 of 41) and Rwanda (5%, 2 of 41). *Fusarium oxysporum* was recovered from a high proportion of the exotic cultivar samples (17 of 19), but only 59% (13 of 22) of the highland cultivar samples yielded this species (Table 3). Of the latter samples, only 3 (14%) were vegetatively compatible with previously described testers (VCG 0124-0125 complex) (Tables 1 and 2). In contrast, 63% (12 of 19) of the exotic samples were vegetatively compatible with VCG 0124 and/or 0125. In summary, two groups of isolates were evident: 1) *F. oxysporum* isolates that were vegetatively compatible with VCG 0124 and/or 0125 testers, and 2) those which could not be categorized (*i.e.* were either not *F. oxysporum* or could not be put in a VCG).

discussion

Although exotic clones were widespread, they were not as prevalent or important as endemic highland AAAs in any of the survey areas. Nonetheless, exotic cultivars were highly appreciated by producers. Gros Michel and Sukari Ndizi were preferred dessert bananas, whereas Pisang Awak was an important beer-making banana, particularly in areas with low rainfall or poor soils. As such, it was used as a substitute for traditional highland beer clones (*e.g.* Muburansika). At the time of the survey, replacements for Pisang Awak were sought in many of the affected areas.

Although only seven different highland cultivars were found to be affected during the survey (as many as 70 highland clones have been recognized; SHEPHERD, 1957), it did not appear that there was a relationship between the cultivars and their food use; cooking and beer types were both affected. There was a clear relationship, however, between altitude and disease development. Although highland cultivars were also prevalent at lower elevations, fusarium wilt did not affect these clones below 1400 masl. The association of high altitude with damage suggests that some sort of predisposition to fusarium wilt occurs at these elevations. Perhaps cool temperatures or other factors found in these locations compromise the resistance of highland cultivars. Cavendish cultivars are known to be predisposed by cold winter temperatures in the subtropics (MOORE *et al.*, 1993).

Disease incidence was usually less than 5% in affected highland fields, even in areas in which the disease had been noted for 20 years. Internal symptoms were much less extensive than on susceptible exotic cultivars, and external symptoms that developed were usually subtle (*e.g.* thin pseudostems and small fingers). Although symptomatic plants were usually rogued by producers, the remaining plants in a mat were often not removed. Asymptomatic plants in affected mats were apparently not considered a liability and ultimately produced acceptable yields.

Table 1 *(cont'd.)*
Descriptions of tissue samples collected during survey of East African highland banana-producing areas.

Sample no.[a]	Cultivar[b]	Location[c]	Altitude[d]	Ident.[e]
RWANDA				
37	Kayinja ABB	Mukoyoyo, Kibungo Prefecture	1 330	0124
38	Kamaramasenge AB	Mukoyoyo, Kibungo Prefecture	1 330	0124-5

[a] Samples 1 - 38 were collected during an INIBAP mission to East Africa in August, 1992, and samples 39 - 42 were collected after the mission by TUSHEMEREIRWE.

[b] East African highland AAA cultivars are italicized. Nonitalicized cultivars are "exotic" (recently introduced to East Africa). Sukari Ndizi, known as Kamaramasenge in Rwanda, is closely related to Kisubi (Ney Poovan), Kayinja is known elsewhere as Pisang Awak, and Gonja is a plantain.

[c] Numbers which precede Uganda locations correspond to those in Figure 1.

[d] Altitude in meters above sea level (masl).

[e] Isolates recovered from tissue samples which were identified as *Fusarium oxysporum* on banana-leaf agar according to NELSON *et al.* (1983) were further characterized for vegetative compatibility via complementation among nitrate-nonutilizing auxotrophic (*nit*) mutants (CORRELL *et al.*, 1987). Some isolates were compatible with previously described VCG 0124, 0125, or 0124 and 0125 (0124-5) testers. Other isolates were not compatible with VCG testers or with other isolates collected during the mission (nc), or were considered to be self-incompatible (si) if *nit*1 and NitM mutants for an isolate did not complement each other. "nonFO" isolates were not *Fusarium oxysporum*.

Overall, these observations suggest that FOC is not very aggressive on highland cultivars. This assumption is supported by data on the isolation of *F. oxysporum* from tissue samples collected during the survey: only 59% of the highland samples yielded this species. Although the unfortunately long interval between sample collection and processing for pathogen isolation may have reduced the number of samples from which *F. oxysporum* was recovered, others who have investigated outbreaks of fusarium wilt on highland clones have also noted that the pathogen is not easily recovered from affected plants (*e.g.* RUTHERFORD, IMI, personal communication).

Low percentages of vegetative compatibility were observed among the highland isolates of *F. oxysporum* and VCG testers (Table 1). However, the results still point out a probable origin of these epidemics. FOC coevolved with banana in Asia (*e.g.* PEG , *et al.*, 1993). VCG 0124-0125, which is known on five continents including

Table 2
Vegetative compatiblity among *Fusarium oxysporum* isolates collected during an East African survey.

Sample no.[a]	Cultivar[b]	Location	Tester comp.[c]	Alt.[d]
VCG 0124-0125 COMPLEX				
31	Niyarma Yik AA	Cibitoke, IRAZ/INIBAP Site, Burundi	0124	900
2	Sukari Ndizi AB	Kawanda ARS, Mpigi District, Uganda	0124	1 210
25	Sukari Ndizi AB	Ryemondo, Bushenyi District, Uganda	0124	1 410
38	Kamaramasenge AB	Mukoyoyo, Kibungo Prefecture, Rwanda	0124-5	1 330
35	Pome AAB	Murama Hill, Rotuna Province, Burundi	0124-5	1 250
1	Kayinja ABB	Kawanda ARS, Mpigi District, Uganda	0125	1 210
29	Kayinja ABB	Mugina, Cibitoke Province, Burundi	0124	1 050
30	Kayinja ABB	Cibitoke, IRAZ/INIBAP Site, Burundi	0124	900
33	Kayinja ABB	Cibitoke, IRAZ/INIBAP Site, Burundi	0124	900
36	Kayinja ABB	Murama Hill, Rotuna Province, Burundi	0124-5	1 250
37	Kayinja ABB	Mukoyoyo, Kibungo Prefecture, Rwanda	0124	1 330
32	Pelipita ABB	Cibitoke, IRAZ/INIBAP Site, Burundi	0124	900
13	*Enyeru*	Rushoroza, Bushenyi District, Uganda	0124	1 650
10	*Kibuzi*	Muhanga, Kabale District, Uganda	0124	1 720
21	*Mbwazirume*	Ishaka, Bushenyi District, Uganda	0124	1 600
NONCOMPATIBLE				
27	Sukari Ndizi AB	Kichwamba, Bushenyi District, Uganda	-	1 207
15	Gros Michel AAA	Butagasi, Bushenyi District, Uganda	-	1 530
41	Gonja AAB	Rubale, Bushenyi District, Uganda	-	1 500
6	Kayinja ABB	Bukinda, Kabale District, Uganda	-	1 860
28	Kayinja ABB	Kichwamba, Bushenyi District, Uganda	-	1 207
7	*Enyabururu* (or *Nakabululu*)	Bukinda, Kabale District, Uganda	-	1 860
12	*Enyeru*	Rushoroza, Bushenyi District, Uganda	-	1 650
17	*Enyeru*	Butagasi, Bushenyi District, Uganda	-	1 530
20	*Enyeru*	Ishaka, Bushenyi District, Uganda	-	1 600
23	*Enyeru*	Rurama, Bushenyi District, Uganda	-	1 400
42	*Enyeru*	Rubale, Bushenyi District, Uganda	-	1 500
19	*Enzirababima*	Butagasi, Bushenyi District, Uganda	-	1 530
16	*Muziranyama*	Butagasi, Bushenyi District, Uganda	-	1 530
22	*Mbwazirume*	Rurama, Bushenyi District, Uganda	-	1 400
24	*Mbwazirume*	Rurama, Bushenyi District, Uganda	-	1 400
3	*Nakyetengu*	Bukinda, Kabale District, Uganda	-	1 860

[a] Sample numbers as listed in Table 1.

[b] East African highland cultivars are italicized. All other cultivars were recently introduced to the region (= "exotic" cultivars).

[c] Isolates of *Fusarium oxysporum* were either compatible with previously described testers (VCG 0124-0125 complex) or incompatible with themselves or other isolates collected during the mission (noncompatible).

[d] Altitude in meters above sea level.

Asia, has been previously associated with outbreaks on exotic clones throughout East Africa (PLOETZ *et al.*, 1992; PLOETZ, 1993; SEBASIGARI and STOVER, 1988). Although two additional VCGs were also evident during the latter work [01212 (Tanzania) and 01214 (Malawi)], the 0124-0125 complex was the most widely spread and important. In the present work, only the 0124-0125 complex was evident (Table 2). Clearly, this clonally related FOC population is causing damage on both exotic and highland clones in the region. Since outbreaks of fusarium wilt on exotic clones probably preceded those on highland clones, introductions of the pathogen on exotic clones are probably responsible for highland outbreaks.

The most plausible avenue by which FOC could have entered East Africa is on exotic cultivars. The first reports of fusarium wilt in East Africa were always on introduced cultivars, and in newly affected areas, the disease has routinely been observed about 20 years after exotic clones were first introduced into an area (*e.g.* PLOETZ *et al.*, 1992). The VCG evidence cited above corroborates the assumption that highland outbreaks are related to prior introductions of FOC on exotics. However, producers in several locations in Uganda indicated that fusarium wilt was actually noted on highland cultivars before exotic cultivars were grown in any given area. In an extreme example, the disease was recognized on highland cultivars more than 20 years before the first exotic (*i.e.* Gros Michel) was planted on a farm in the Bushenyi District (Butagasi, site 4 in Figure 1C). The following explanations are proposed as possible reasons for these observations.

Producers may have confused nutritional deficiency symptoms, weevil borer or nematode damage with fusarium wilt symptoms. Nutritional problems are apparently new to many of the affected areas, as are borers and nematodes, thus explaining producers' initial confusion.

Alternatively, FOC could have moved into an area on infected planting material of highland cultivars, on infested farm tools, or in soil. Since fusarium wilt symptoms are not very conspicuous on highland bananas, infected suckers from fields originally contaminated by infected exotic clones may have been used to plant new areas. In addition, movement of FOC to new areas can also occur via machetes, shovels and other farm implements which may partially explain the above situations.

In summary, historical and genetic evidence indicate that recently introduced FOC populations have caused outbreaks of fusarium wilt on exotic clones in East Africa. Based on the present results, the same pathogen populations are also responsible for at least some of the damage observed on the highland clones. At this time, the origins and roles of the remaining incompatible highland isolates are unknown.

It is assumed that significant damage will continue to occur on susceptible exotic cultivars throughout the region. However, the potential extent of damage which could be expected on highland clones is not clear. Given the importance of these bananas in the highland regions of East Africa and the severe damage which was apparent on at least one farm during the survey (Muhanga, site 2, Figure 1C), continued assessment of this situation is warranted.

Table 3
Category summaries for East African samples.

	***Fusarium oxysporum* recovered**[a]	**Vegetatively compatible**[b]	**Noncategorized (nonFO + noncomp.)**[c]
Cultivar			
Highland AAA	59% (13/22)	14% (3/22)	86% (19/22)
Exotic	89% (17/19)	63% (12/19)	37% (7/19)
Country			
Uganda	66% (21/32)	19% (6/32)	81% (26/32)
Burundi	100% (7/7)	100% (7/7)	0%
Rwanda	100% (2/2)	100% (2/2)	0%

[a] Percentage of East African samples from which *Fusarium oxysporum* was recovered.

[b] Percentage of *Fusarium oxysporum* isolates that were vegetatively compatible with previously described VCG 0124 and/or 0125 testers.

[c] Percentage of all isolates that were not *Fusarium oxysporum* and not vegetatively compatible.

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