Resistance to *Fusarium oxysporum* f. sp. *cubense* Tropical Race 4 in African Bananas

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Abstract

Bananas (*Musa* spp.) constitute one of the most important staple food crops in Africa. Two major groups of bananas exist in Africa: the East African highland banana (EAHB, AAA) in East and Central Africa, and the plantains (AAB) in West Africa. Neither of these groups has been affected by *Fusarium oxysporum* f. sp. *cubense* (Foc) race 1, which is the primary fungal pathogen in the continent for banana. The susceptibility of EAHB and plantains to Foc tropical race 4 (TR4) is unknown, and was the focus of this study. A collection of 14 genetically diverse EAHB and plantain cultivars were evaluated in China and the Philippines to determine field resistance to Foc TR4. A field heavily infested with TR4 was used in Guangzhou, China, and another one in Davao City in the Philippines. Disease incidence was determined according to leaf yellowing, pseudostem splitting and confirmed rhizome discoloration. The fungus was also re-isolated from diseased materials and identified by polymerase chain reaction (PCR) using Foc TR4-specific primers. All EAHB and plantain cultivars, except EAHB 'Ibwi', proved to be resistant to the tropical strain of Foc race 4, with disease incidence ranging from 0-5% only. In the Philippines, 'Ibwi' developed Fusarium wilt at an incidence of 32% compared to 46% for 'Williams' and 79% for 'Grand Naine's (both AAA genome, Cavendish subgroup). Similar results were observed in China where most all the cultivars were severely affected by the corm weevil. Our preliminary results indicate that African bananas are less vulnerable to Foc TR4 compared with some susceptible cultivars in Asia. A more extensive screening of African bananas is required considering the diversity of EAHB and plantains grown in that region.

INTRODUCTION

Fusarium wilt of banana has widely been considered as one of the most devastating diseases in agricultural history because of the total destruction it caused of banana plantations in Central America in themid-19thcentury. The consequent replacement of susceptible Gros Michel withRace1-resistant Cavendish cultivars has saved the commercial banana industry. New outbreaks of the disease in Asia, caused by *Fusarium oxysporum* f. sp. c*ubense* (Foc) Tropical Race 4 (TR4)(Molina et al., 2008; 2009), have raised concerns that the disease is once again a serious threat to global banana production, and especially to the livelihoods and food security to small-scale farmers. This is particularly relevant to food security in Africa, where the East African highland bananas (EAHB, AAA genome) and plantains (AAB genome) form the staple diet and provide a major source of income for millions of Africans.

During the 2009 ISHS-ProMusa International Banana Symposium in China, experts recommended assessing the risk of the destructive Foc TR4 to EAHB and plantains. Bioversity International developed a proposal that was eventually funded by the Global Crop Diversity Fund to evaluate some representative EAHB and plantains against TR4.The study was conducted to establish the resistance/susceptibility of EAHBs and some plantains to Foc TR4 in collaboration with African and Asian research institutions under the coordination of Bioversity International. The outcome of this project should be of great significance not only to Africans, but also to the Americas, where plantain is widely grown. The research is a pro-active effort to select or develop material with resistance to the pathogen for Africa. It provides an indication of risk and vulnerabilities of these important cultivar groups to the damage and impact of the disease should it eventually occurs in the region (*note: at the time of writing of this article, Foc TR4 was already confirmed present in a Cavendish plantation in Mozambique, Africa. Viljoen and Molina, 2013, pers. commun.).*

METHODOLOGY

Seven EAHB and seven plantains were sent from the International Transit Centre (ITC) in Belgium for evaluation in China and the Philippines, where Foc TR4 is now causing epidemics in commercial plantations. Some of the accessions however did not survive the nursery stages in both locations. In the Philippines, seven EAHB and two plantains were tested, alongside one Philippine local cultivar and two common Cavendish cultivars as susceptible checks. In China, the same seven EAHB, four plantains, and three Cavendish cultivars were included.

In the Philippines, the study was conducted in a heavily infested commercial farm in Callawa, Davao City. Callawa farm is located at 7°11'47"N Lat. and 125°33'57"E Long., approximately 22m above sea level. The area is characterized by a uniform distribution of rainfall, temperature, humidity and air pressure. It has no pronounced wet or dry season. Weather predictability makes it highly conducive to agricultural production. Temperature ranges from 21 to 35°C and average rainfall is up to 2,000 mm yearly. The Callawa field was no longer economically productive with ‘Grand Naine’ due to heavy TR4 infestations. The identity of the Foc isolate was determined through the primer of Vegetative Compatibility Group (VCG) 01213/16 developed by Dita et al. (2010).The trial was planted from July to September 2011, set up in Randomized Complete Block Design (RCBD), with 20

plants/cultivar/plot, replicated 5 times. In China, the field trial was carried out in Guangzhou, China. Experimental site is located at 23° 1' 13" N Lat. and 113°45' 6" E Long., at 7m above sea level. The province of Guangdong is characterized with tropical and subtropical monsoon climate with long time summer and abundant rainfall. The average temperature ranges from 12°C in winter and 28°C in summer. Average annual rainfall is from 1,500mm to 2,000mm. The area also experiences typhoons in summer.

Field resistance/susceptibility reactions of the various cultivars were evaluated by assessing the incidence of Foc infection on a weekly basis. Disease incidence was determined based on the typical external Foc symptoms that include yellowing of leaves starting at older leaves and/or pseudostem splitting. Once the plants showed apparent symptoms, they were cut down cross-sectionally at pseudostem level to verify internal vascular discolorations indicative of Foc infection. Plants positive for Foc infection were recorded and subsequently eradicated. TR4 was verified by isolating the pathogen from infected pseudostem samples and tested against the primer of VCG 01213/16 developed by Dita et al. (2010).

RESULTS AND DISCUSSION

Table 2 shows the incidence of Foc infected plants of different cultivars in the field trial in the Philippines. Results show that, with the exception of 'Ibwi' (AAA genome, EAHB subgroup), all the African cultivars sustained relatively low levels of disease ranging from 0-5%, while susceptible checks 'Williams' and 'Grand Naine' (both AAA genome, Cavendish subgroup)showed 46 and 66% disease incidence, respectively. 'Ibwi' developed Fusarium wilt symptoms at an incidence level of 32%. A susceptible local cultivar ('Lakatan', AAA genome, Cavendish subgroup) sustained 96% incidence. In China, the results were even more significant with all the EAHB and plantains being free of disease while the susceptible control 'Baxi', a local Cavendish, sustained 70% disease (Table 3). A resistant Cavendish somaclone, 'GCTCV 119', developed no symptoms.

The fungus was also re-isolated from diseased materials and identified byusing polymerase chain reaction (PCR) with Foc TR4-specific primers. While this preliminary study showed favorable assessment of EAHB and plantains from Africa, a more extensive screening of African bananas is required considering the diversity of EAHB and plantains grown in that region. The results however indicate promising prospects in terms of lower vulnerability of EAHB and plantains to Foc TR4.

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Tables

Table 1. African and Cavendish cultivars evaluated for resistance to Fusarium wilt Tropical race 4 in Davao City, Philippines and in Guangzhou, China.

ITC code	Cultivar	Genome	Subgroup	Evaluated in the Philippines	Evaluated in China
ITC0081	Igitsiri	AAA	EAHB	x	x
ITC0084	Mbwazirumi	AAA	EAHB	x	x
ITC0166	Ingagara	AAA	EAHB	x	x
ITC0179	Inkira	AAA	EAHB	x	x
ITC0217	Akpakpak	AAB	Plantain	x	x
ITC0519	ObubitNtanga	AAB	Plantain	x	x
ITC1354	Enzirabahima	AAA	EAHB	x	x
ITC1355	Kazirakwe	AAA	EAHB	x	x
ITC1465	Ibwi	AAA	EAHB	x	x
	Ihitisim	AAA	Plantain		x
	Curare	AAA	Plantain		x
ITC0570	Williams	AAA	Cavendish	x	x
	Baxi	AAA	Cavendish		x
	GCTCV 119	AAA	Cavendish		x
	Grand Naine	AAA	Cavendish	x	
	Lakatan	AAA	Lakatan	x	

Table 2. Disease incidence of Fusarium wilt, Moko bacterial wilt and bunchy top observed in African cooking banana and Cavendish cultivars planted in Davao City, Philippines (2011 to 2012, 75 weeks after planting).

Cultivar	Fusarium wilt incidence (%)	Moko bacterial wilt Incidence (%)	Bunchy top incidence (%)
Igitsiri	3	0	0

Mbwazirumi	2	2	7
Ingagara	5	0	2
Inkira	4	0	0
Akpakpak	1	0	0
ObubitNtanga	0	0	0
Enzirabahima	1	0	1
Kazirakwe	1	0	6
Ibwi	29	0	11
Williams	46	0	3
Lakatan	91	0	5
GrandNaine	66	1	4

Table 3. Disease incidence of Fusarium wilt and banana weevil damage observed in African cooking banana and Cavendish cultivars planted in Guangzhou, China (2011 to 2012, 52 weeks after planting).

Cultivar	Fusarium wilt incidence (%)	Weevil incidence (%)
Ingagara	0	8
Inkira	0	15
Ibwi	0	43
Kazirakwe	0	31
Igitsiri	0	16
Mbwazirume	0	6
Enzirabahima	0	10
Obubit	0	0
Akpakpak	0	15
Curare	0	7
Ihitisim	0	0
Williams	69	0
Baxi (local check)	70	0
GCTCV 119	0	0