

# CONFIRMATION OF TROPICAL RACE 4 OF *Fusarium oxysporum f. sp. cubense* INFECTING CAVENDISH BANANAS IN THE PHILIPPINES\*

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*Fusarium* wilt disease of banana (also known as Panama Disease), caused by *Fusarium oxysporum f. sp. cubense* (*Foc*), is a major concern of the banana industry, having wiped out Gros Michel plantations in Central America in the 1950s and consequently caused a costly shift to the Cavendish variety. To date, Cavendish remains resistant to the *Fusarium* strain that prevails in Central America. However, a virulent strain that can attack the Cavendish was found causing epidemics in Asia. Known as Tropical Race 4 (TR4), this pathogen destroyed commercial plantations of Cavendish in Taiwan, Northern Territory of Australia, Indonesia, Malaysia, and China making their banana exports less competitive. For many years TR4 has not been found in the Philippines, contributing to its dominance in the export banana trade in Asia.

This paper reports the first study to confirm the occurrence of *Fusarium* Tropical Race 4 in the Philippines.

**The new *Fusarium* wilt outbreaks.** In 2002, an outbreak of *Fusarium* wilt disease was observed in a highland Cavendish farm in Southern Philippines. Subsequently, from 2004 to 2005, new incidences of *Foc* infections were observed in some traditional lowland commercial Cavendish farms. Although occurrences of *Fusarium* wilt disease have been reported in Cavendish farms between the period of 1970s and the 90s, these were associated with a less virulent strain of *Foc*. These previous incidences never became significant constraints to production. However, as the new infections became more aggressive and rapidly spreading, the new epidemics were suspected to have been caused by the dreaded TR4.

To quantify the epidemics, two commercial Cavendish farms in Southern Philippines were monitored for *Fusarium* wilt incidence from 2005 to 2007. Plants showing the typical external and internal symptoms (Figure 1) were monitored on a regular basis. Once an infected plant is identified, the whole mat (hill) and the immediate surrounding mats were eradicated (Figure 2). Table 1 shows the dramatic increase in incidence of the disease during the three-year period.

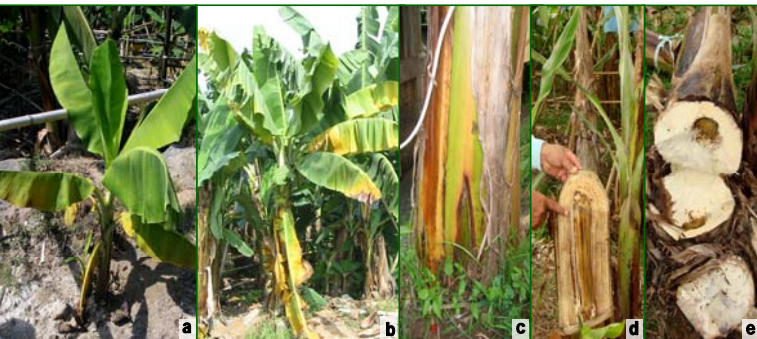


Figure 1. External and internal symptoms of *Fusarium* wilt on Cavendish variety: yellowing of leaves that starts on older leaves, on young (a) and older (b) plants; pseudostem splitting (c); dark brown discoloration on vascular tissues as shown in cross sections of pseudostem (d and e)



Figure 2. Farms affected by *Fusarium* wilt epidemic: the sporadic appearances of *Fusarium* wilt disease during the early stage of the epidemic (a); burning of rice hull to eradicate host and pathogen (b); abandoned area because of extensive disease incidence (c)

Table 1. Monthly incidence of *Fusarium* wilt disease on two Cavendish plantations in Davao City, Philippines

	Buhangin, Davao City*			Calinan Davao City**		
	2005	2006	2007	2005	2006	2007
January	146	200	835	342	340	1110
February	167	164	777	453	480	1301
March	104	153	795	280	236	958
April	113	227	604	298	365	601
May	97	419	480	428	219	634
June	250	795	576	272	313	648
July	235	2301	1650	121	354	670
August	216	2480	1698	150	400	773
September	179	1422	1345	216	356	654
October	121	1064	1038	443	145	967
November	120	1061	940	430	412	1670
December	124	816	1358	277	723	2835
<b>Total:</b>	<b>1,872</b>	<b>11,102</b>	<b>12,096</b>	<b>3,710</b>	<b>4,343</b>	<b>12,821</b>
<b>Average</b>	<b>156</b>	<b>925</b>	<b>1008</b>	<b>309</b>	<b>361</b>	<b>1068</b>

\*400 hectares, 25 meters above sea level  
\*\* 28 hectares, 465 meters above sea level

**Verifying the VCG of the recent infections of *Foc*.** Infected plant samples were collected from highland and lowland Cavendish banana farms in Davao, Southern Philippines from September to December 2005 and were sent to the Forestry and Agricultural Biotechnology Institute (FABI) of the University of Pretoria in South Africa for Vegetative Compatibility Group (VCG) testing. VCG was determined using the technique described by Puhalla in 1985. In this technique, isolates were assigned to VCGs based on heterokaryon formation between complementary nitrate-nonutilizing (*nit*) mutants produced on media supplemented with chlorate. *Nit*-mutants were produced for all isolates as well as for the known VCG tester strains. The *nit-1* and *nit-3* mutants were then paired with each of the *nit-M* tester strains on minimal medium (MM) as described by Correll and his group in 1987. *Nit-M*, *nit-3* and *nit-1* mutants of the same isolate were also paired to test for self-compatibility. Complementary *nit*-mutants that formed dense, wild-type growth on MM were assigned to the same VCG. Vegetatively incompatible isolates were detected by their inability to form a heterokaryon when paired on MM.

Results of the test confirmed that the recent infections of *Fusarium* wilt in commercial Cavendish plantations in the Philippines were caused by *Foc* isolates belonging to VCG 01213, VCG 01216 and VCG 01213/16 complex, the VCGs associated with TR4 (Table 2). These are the same VCGs that caused serious epidemics of *Fusarium* wilt disease in Indonesia and Malaysia in the early 1990's. This finding is highly significant as the presence of TR4 poses a serious threat to the Philippine export Cavendish banana and to the local cultivars as well, which are also susceptible to TR4.

Table 2. VCG classification of the various *Foc* infected samples from Southern Philippines

Source Variety	Genome	Source Location	VCG
Grande Naine	AAA	Monkayo, Compostela Valley	01213
Grande Naine	AAA	Calinan, Davao City	01213
Grande Naine	AAA	Toril, Davao City	01213
Grande Naine	AAA	Baguio, Davao City*	01216
Tall Williams	AAA	Toril, Davao City	01216
Latundan	AAB	Calinan, Davao City*	01216
Grande Naine	AAA	Baguio, Davao City*	01213/16
Grande Naine	AAA	Buhangin, Davao City	01213/16
Grande Naine	AAA	Macopa, Compostela Valley	01213/16
Umalag	AAA	Buhangin, Davao City	01213/16
Umalag	AAA	Buhangin, Davao City	01213/16
Umalag	AAA	Buhangin, Davao City	01213/16
Grande Naine	AAA	Tugbok District, Davao City	01213/16
Williams	AAA	Baguio, Davao City*	01213/16
Grande Naine	AAA	Davao del Norte	0122
Cardaba	BBB	Compostela Valley	0126
Cardaba	BBB	Compostela Valley	0126

\* 465 meters above sea level  
Locations without asterisk are at 20-30 meters above sea level

The Philippines is the leading banana exporting country in Asia. In 2006, the country registered its highest export volume of 2.04 million MT, becoming the world's second largest banana exporter (Figure 3). For this reason, the Philippine government, private banana companies and Bioversity International, are collaborating to manage the disease and prevent further spread of *Foc* TR4 in the country.

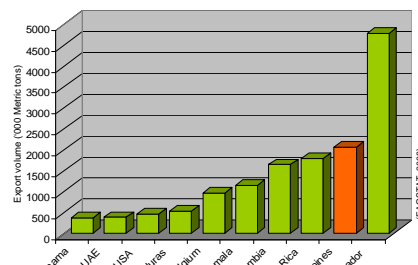


Figure 3. Export volume ('000 Mt) from top banana exporting countries

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