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Incidence and Distribution of Fusarium Wilt Disease of Banana in Indonesia

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Abstract

Fusarium wilt is a major constraint of banana production in Indonesia. Field observations and sample collections, facilitated by two ACIAR (Australian Centre for International Agricultural Research)-projects, were undertaken to generate a Fusarium wilt distribution and incidence map, based on vegetative compatibility groups (VCG). The activities were conducted from 2006 to 2009 in 15 banana-producing provinces, where each province involved two districts, each encompassing two banana-producing areas. Fifteen to 20 banana orchards were observed, and vascular strand samples were collected from the same fields. Incidence of Fusarium wilt ranged from 0.08 to 100%, with an average of 23.99 ± 14.41%. Seven VCGs of *Fusarium oxysporum* f. sp. *cubense* (Foc) were initially identified, namely VCG 0120-0120/15, 01213/16, 01218, 0123, 0124/5 and 0126. One third of the total isolates was identified to be Foc tropical race 4 (TR4) VCG 01213/16, which is distributed widely in almost all provinces, infecting local cultivars 'Barangan' (AAA), 'Raja' (AAB) and 'Ambon Hijau' (AAA), as well as other cultivars of different ploidies and genomes. Besides mismanagement by banana farmers, the wide distribution of the disease may be due to the movement of planting materials along with transmigration of people from Java to other islands.

INTRODUCTION

Fusarium wilt, also known as Panama disease, caused by *Fusarium oxysporum* f. sp. *cubense* (Foc), causes a serious threat to banana production (Stover and Simmonds, 1987; Pegg et al., 1993; Nasir et al., 1999), and is considered as one of the most destructive plant diseases in recorded history (Moore et al., 1995). Identified as a soil-borne pathogen, Foc strikes almost all commercial cultivars of banana (Buddenhagen, 1995; Ploetz and Pegg, 1997; Pittaway et al., 1999; Stover, 1962; Ploetz and Pegg, 2000; Hermanto and Setyawati, 2002a). It is highly variable and complex in term of races and strains of the pathogen, and the banana genomes it attacks (Stover and Buddenhagen, 1986; Pegg et al., 1996; Ploetz and Pegg, 1997; Ploetz and Pegg, 2000). By the 1950s, 40,000 hectares of Gros Michel (AAA) plantations in Latin America were devastated by Fusarium wilt (Simmonds, 1962). It is predicted that the total damage to Gros Michel, Cavendish and other local bananas due to Fusarium wilt reaches 100,000 ha, mainly in big banana plantations in Asia, which are sporadically destroyed by tropical race 4 that originated from tropical Asia (Hwang and Ko, 2004) and is much more virulent than other races.

Even though Fusarium wilt greatly affected the banana industry in Indonesia, accurate information on its economic impact is very limited. Nurhadi et al. (1994) reported that losses caused by Fusarium and bacterial wilt suffered by farmers in Lampung reached 2.8 billion rupiah during the 1993-1994 harvesting period. Another report mentioned that an average of 2.11 million mats of banana were devastated every year from 2003 to 2007 (Soekirno, 2009). Infection was also reported on 'Kepok Kuning' (ABB, Saba subgroup) (Nasir et al., 1999), 'Barangan' (AAA), 'Rajasere' (AAB, Silk subgroup) and 'Tanduk' (AAB, plantain) (Hermanto and Setyawati, 2002a).

A survey, facilitated by two Australian Centre for International Agricultural Research (ACIAR)-funded projects, aimed to analyse actual loss caused by Fusarium wilt, map its distribution and identify potential factors affecting the loss and distribution.

MATERIALS AND METHODS

A survey, including disease evaluation, samples collection and interviews, was conducted in 15 provinces in Indonesia (Fig. 1) from September 2006 till February 2009. In each province, two districts were visited during the survey, except in Nagroe Aceh Darussalam (NAD) and West Java where four districts were visited, and each district involved two banana production centres, represented by subdistricts with high banana populations based on secondary data collected from '*Dinas*' (Local Agricultural Office). Observation and sample collection (Moore et al., 1995) were done on 15-20 banana farms, while interviews were carried out with 15-25 respondents of banana farmers. The selected farmers had >100 mats, were head of the family (decision maker of the farm), directly involved in the banana business and available to be interviewed. The respondents were selected using simple random sampling and interviewed individually.

The questionnaire encompassed a list of questions regarding banana cultivars (affected and unaffected), symptoms, agro-ecological and climatic parameters, the production system, farmers' broad socio-economic profile, perceptions of the disease and management practices. Collected samples were maintained and single spores processed at the Indonesian Tropical Fruit Research Institute (ITFRI), while vegetative compatibility group (VCG) analysis was done at the Queensland Department of Primary Industries and Fisheries (QDPI&F).

RESULTS AND DISCUSSION

Incidence of Fusarium Wilt

The survey revealed that Fusarium wilt incidence ranged from 0.08 to 100% (Table 1). Besides differences between newly infested and advanced endemic areas, incidence variation might be due to variability in cropping system and implementation of cultural practices at farmer level. The survey found that Fusarium wilt incidence was more problematic in farms/areas where banana were cultivated in a monoculture system. The worst situation was found in NAD where the farmers unknowingly collected suckers from infected farms for their planting material. The fact that newly infected suckers do not show any visible symptoms increases the risk for the further development of the plantation. In addition, lack of farmers' knowledge of the mode of infection and distribution of the pathogen also contributes to the development of the disease.

Fusarium wilt incidence in Indonesia is changing over time and in space. Data show that the average incidence in the 15 provinces was as high as 23.99 ± 14.41%. Assuming that the average price for banana is Rp. 1000 per kilogram, and at a national production of 5.037 million tonnes in 2006 (Harisno et al., 2007), this incidence level could cause losses of as much as 1.21 trillion rupiah per year. In some regions, such as in Kalimantan, Sulawesi and Papua, it is difficult to differentiate between Fusarium and bacterial wilts when the two diseases co-exist. A report delivered by the Directorate of Plant Protection for Horticulture stated that average annual incidence of the two diseases from 2003 to 2008 reached 3.6 million mats (Soekirno, 2009). In Indonesian banana cropping systems which are dominated by subsistence farmers, one mat does not merely consist of one to three plants, but can contain more than five stems with two to three of them in fruiting stage. Therefore, actual losses caused by the wilts are higher than what has been calculated.

Vegetative Compatibility Group Variation and their Geographic Distribution

Eight VCGs were found, namely race 1 – VCG 0123, 0124/5, 0126 and 01218; and race 4 – VCG 0120, 0121, 01213/16 and 01219 (Table 2). The first four were already reported in Indonesia by Ploetz and Pegg (2000). This is however the first report of Foc tropical race 4 (TR4) VCG 01213/16 found in Kalimantan, where it is becoming a serious threat to the potential of this region for the development of banana. In general, TR4 VCG 01213/16 and race 4 VCG 01218 which represented 80.96% of the total collected isolates are a potential threat to the banana industry in Indonesia. A warning was also issued by Gulino et al. (2009a,b) who confirmed that TR4 is more widespread in Indonesia than previously thought.

More than 75% of the isolates were collected from Sumatera and Java, which were represented by NAD, West Sumatera, West Java and Yogyakarta Special Area (Daerah Istimewa Yogyakarta). Specifically for NAD, most of the isolates were collected from 'Barangan' which is extensively grown in this province. The high diversity in banana cultivars combined with old cultivation/development of banana with settlement of people in Java resulted in high VCG variation, with six of the seven VCGs identified (Table 2, Fig. 2). Co-evolution between banana and the pathogen might have happened. Fewer isolates were collected from Kalimantan, Sulawesi and Papua (previously called Irian Jaya) because these areas have lower banana production compared with Java and Sumatera.

Free movement of banana materials, as well as the pathogens, from one place to another in Indonesia complicates explaining the role of the biological border constructed under Wallace's or Weber's line. VCG 0126 that was previously reported only in Papua was collected in Kalimantan during this survey. Similarly, VCG 01219, previously reported in Java and Sumatera (Ploetz and Pegg, 2000), had crossed the Wallace line to North Sulawesi (Fig. 2). Tracing the movement of the pathogen through molecular characterisation may give new insights.

Our knowledge of affected banana cultivars has also progressively developed. 'Pisang Kepok' (ABB, Saba type) that was assumed susceptible only to race 2 was found affected by several VCGs grouped to race 4 (Table 3). Similar results were also found for 'Ambon Kuning' (AAA, Gros Michel) and 'Rajasere' (AAB, Silk). A more in-depth discussion on the relationship between the pathogen and banana cultivars based on the results of this survey argues that cultivars tend to have certain VCGs associated which may bear some relation to the distribution of planting material from a common origin (Daniells et al., this volume).

Possible Factors Influencing Distribution

1. Transmigration. The Indonesian population has been concentrated on Java Island. From the 1950s onwards, the Indonesian government has implemented a transmigration policy from Java and Bali Islands to the remaining islands. Not less than 924,192 families or 5,771,240 persons have been moved during the period of 1950-2000 (Adhiati and Bobsien, 2001). Besides being the most populated island, Java is also the main banana production centre with high diversity of banana cultivars (Hermanto and Setyawati, 2002b; Harisno et al., 2007). Banana is believed to have co-evolved with pests and diseases in this area. Transmigration, consequently, has contributed to the distribution of cultivars, and at the same time, the pests and diseases, since most of the transmigrants brought in and planted banana, especially 'Kepok' for supplying food wrap. The disease thus unintentionally and artificially spread since humans have been the key factor in the global distribution of Fusarium wilt (Ploetz and Pegg, 2000).

2. Farmer habit. The survey showed that 97% of the banana farmers used suckers to develop their new farms, and around 50% of them collected the materials from other farms (Fig 3). In areas like Indonesia where Fusarium wilt is widely distributed, this practice promotes the spread of the disease. Since infected rhizomes are usually free of visual symptoms, it is not uncommon for the pathogen to be introduced to new areas.

CONCLUSION

Incidence of Fusarium wilt ranged from 0.08 to 100%, with an average of 23.99 ±14.41%. Seven VCGs of Foc were initially identified, namely VCG 0120-0120/15, 01213/16, 01218, 0123, 0124/5 and 0126. One third of the total isolates was identified to be Foc TR4 VCG 01213/16, which is distributed widely in almost all provinces, infecting local cultivars 'Barangan', 'Raja' and 'Ambon Hijau', as well as other cultivars of different ploidy and genomes. Transmigration and farmer mismanagement practices are factors affecting disease distribution.

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Tables

Table 1. Fusarium wilt incidence in 15 provinces in Indonesia (2006-2009).

Province	Wilt incidence (%)			
	Average	Standard deviation	Minimum value	Maximum value
NAD[1]	13.90	16.42	0.15	62.50
North Sumatera	19.93	25.24	0.00	54.54
West Sumatera	33.94	25.55	0.31	100.00
Lampung	14.78	18.33	0.08	50.00
West Java	4.88	6.05	0.14	25.00
DIY[2]	21.33	19.13	2.47	75.00
East Java	17.28	9.69	2.50	33.33
West Kalimantan	8.10	7.15	3.13	25.00
Central Kalimantan	16.26	15.81	0.30	50.00
South Kalimantan	21.13	24.14	2.00	90.00
East Kalimantan	42.91	32.57	5.00	100.00
South Sulawesi	60.38	32.13	20.00	100.00
Southeast Sulawesi	27.00	2.83	25.00	29.00
North Sulawesi	17.31	16.92	1.18	66.67
Papua	21.62	15.09	5.00	42.86
Average	23.99	14.41	0.08	100.00

[1] NAD = Nangroe Aceh Darussalam; [2] DIY = Daerah Istimewa Yogyakarta (Yogyakarta Special Area).

Table 2. Distribution frequency of *Fusarium oxysporum* f. sp. *cubense* vegetative compatibility groups (VCG) in some provinces in Indonesia.

Province	VCG							%
	0120-0120/15	01213/16	01218	01219	0123	0124/5	0126	
NAD[1]		19	6					23.81
West Sumatera		22	4					24.76
West Java	2	2	4		3	1		11.43
DIY[2]	4	9	2	2				16.19
West Kalimantan		4	3					6.67
Central Kalimantan					1		2	2.86
East Kalimantan		1						0.95
South Kalimantan							1	0.95
Southeast Sulawesi		1					1	1.90
North Sulawesi		7		2				8.57
Papua		1					1	1.90
%	5.71	62.86	18.10	3.81	3.81	0.95	4.76	

[1] NAD = Nangroe Aceh Darussalam; [2] DIY = Daerah Istimewa Yogyakarta (Yogyakarta Special Area).

Table 3. Natural occurrence of *Fusarium oxysporum* f. sp. *cubense* vegetative compatibility groups (VCG) on banana cultivars in Indonesia.

Banana cultivars	Genome, group	VCG							%
		120 0120/15	01213/ 16	01218	01219	0123	0124/ 5	0126	
Rejang	AA, cv Rose		1						0.90
Ambon Hijau	AAA, Cavendish	1	13	1				1	14.41
Ambon Kuning	AAA, Gros Michel	3	5		1	1			9.01
Barangan	AAA, Lakatan		28						25.23
Rajasere	AAB, Silk	2	2	3	1	2			9.01
Ketan	AAB		1						0.90
Mysore	AAB			1					0.90
Raja	AAB		15						13.51
Pulo	AAB?						1		0.90
Awak	ABB, Awak			10		2			10.81
Kepok[1]	ABB, Saba	1	5	2	2			3	11.71
Panjang			1						0.90
Nangka				1					0.90
M. schizocarpa	AA_w							1	0.90
%		6.31	63.96	16.22	3.60	4.50	0.90	4.50	

[1] *Fusarium semitectum* was detected from Kepok collected from West Sumatera.

Figures

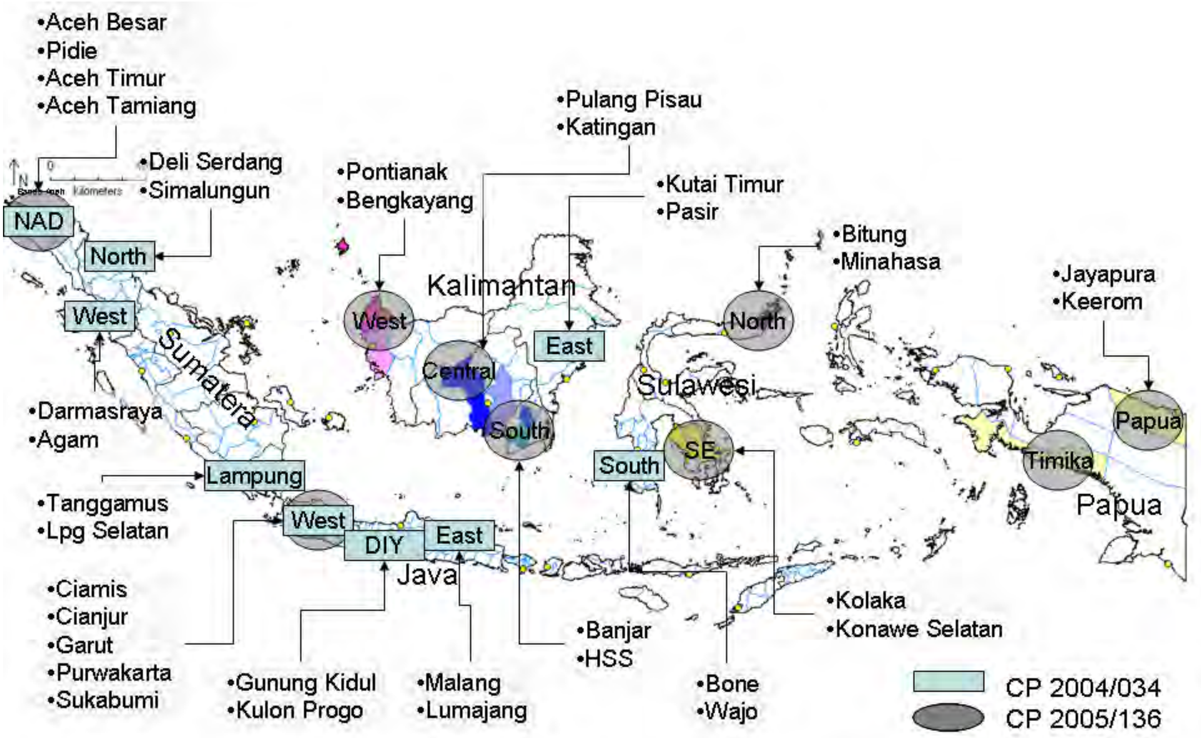
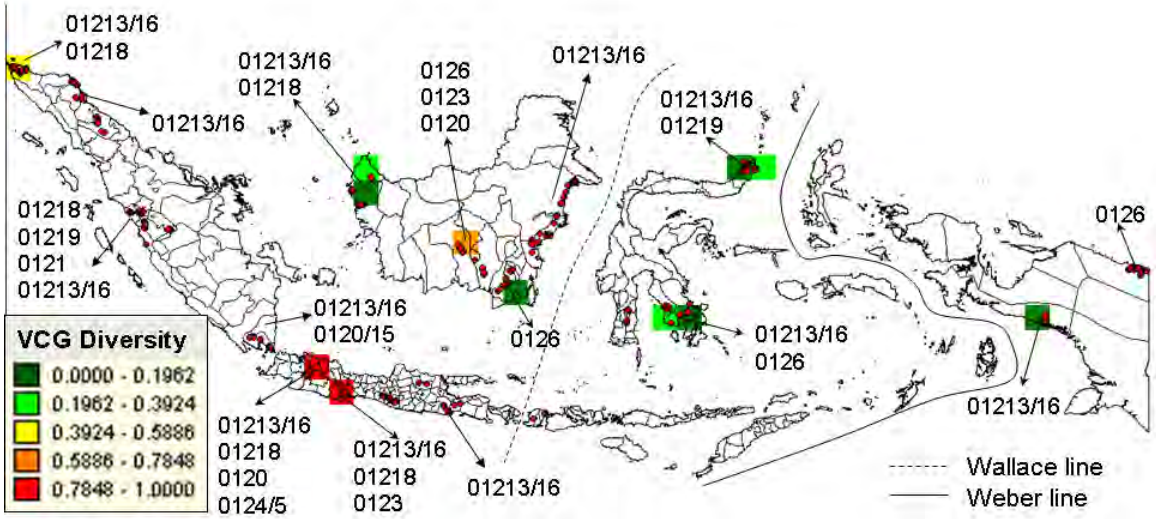


Fig. 1. Surveyed districts from 15 provinces of Indonesia.



Note: A higher score of VCG diversity represents higher variation in each province.

Fig. 2. Distribution of *Fusarium oxysporum* f. sp. *cubense* vegetative compatibility groups (VCG) in 11 provinces in Indonesia (2006-2008).

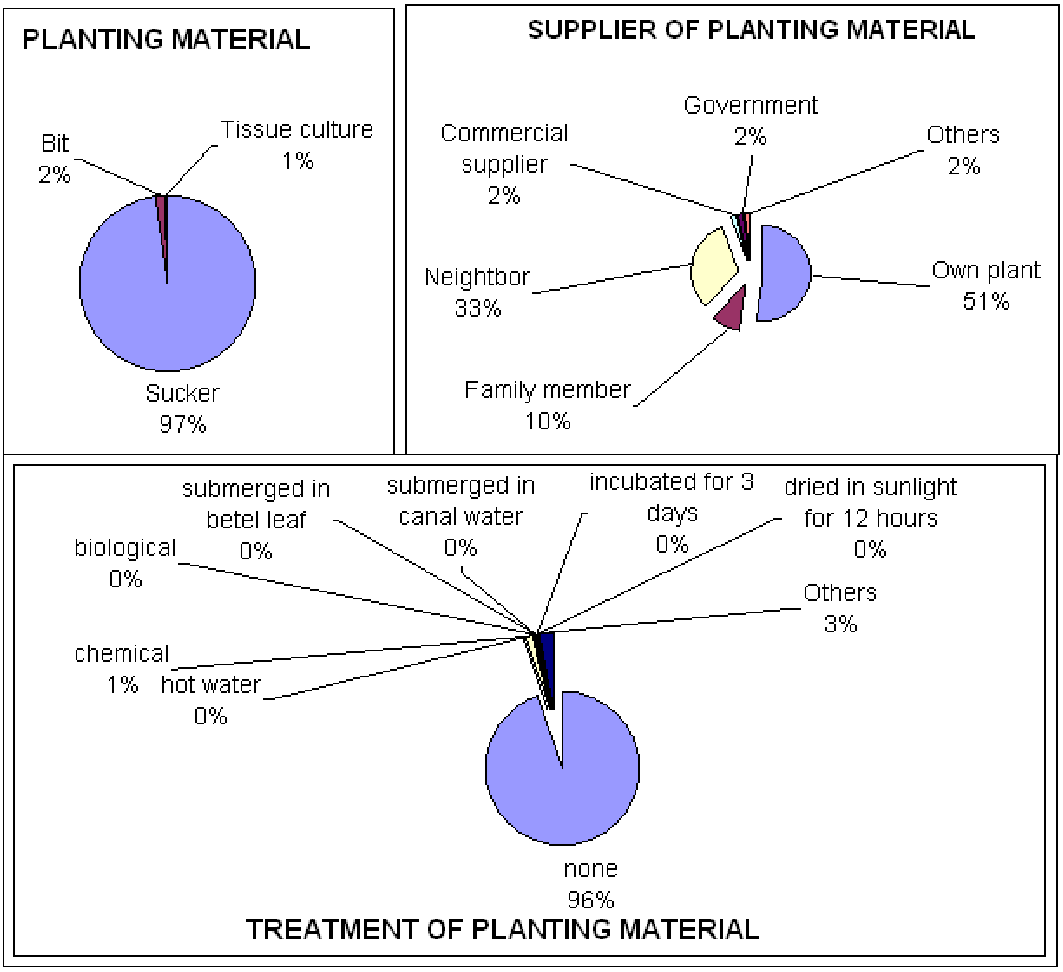


Fig. 3. Farmers' practices of collecting and treating banana planting materials.