Fusarium Wilt of Cavendish Banana in a Commercial Farm in Malaysia

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Introduction

Prior to 1960, *Fusarium oxysporum* f.sp. *cubense* (*Foc*) of banana, also called Panama disease and caused by Fusarium wilt race 1, destroyed more than 40 000 ha of bananas in Central and South America over a period of 50 years (Stover 1962). The disease has led to the entire replacement in the region of the susceptible cv. Gros Michel with resistant Cavendish cultivars. However, race 4 of *Foc* was established in Taiwan and since 1977 has become widespread in banana-growing areas of Taiwan (Su *et al.* 1986), attacking the Cavendish cultivars. Outbreaks of *Foc* on Cavendish cultivars have since been reported from Australia, South Africa, the Canary Islands, the Philippines, Indonesia and recently Malaysia.

Commercial cultivation of Cavendish in Malaysia

Commercial cultivation of Cavendish banana in Malaysia started in 1989 with the planting of a commercial farm in the state of Johor in 1989/90. A total of 376 ha was planted by Johor Tropical Product (JTP) near Kulai, using cultivar Grand Naine. Subsequently, Kulim Montel Farm (KMF) in Johor Bahru, Johor, carried out a 349 ha commercial planting of Cavendish banana. In total, 160 and 189 ha were planted in 1992 and 1993, respectively, using the same cultivar. All the above plantings used 3-month-old seedlings derived from meristem culture plantlets. This paper outlines our experiences with the outbreak of *Foc* in the 1992 (B92) and 1993 (B93) plantings in KMF.

Incidences of *Foc* in Kulim Montel Farm

The first five plants in the 1992 planting (B92) were infected in two separate localized areas 6 months after field planting (Table 1). In the 1993 planting (B93), the first three cases of infection were noticed in an isolated spot 7 months

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after field planting. Apparently healthy plants surrounding these infection sites were subsequently infected. These 'hot spots' then enlarged themselves radially. Disease spots seemed to be 'sprouting' in various areas in the farm as time passed. It was noted in both fields that the number of infected plants remained low for the first year after the initial detection. It took about 1.5 years for the rate of infection to reach 1 plant ha^{-1} $month^{-1}$ (Table 2). Thereafter the rate of infection increased geometrically (Fig. 1).

In B92, the rate of infection reached 2.75 plants ha^{-1} $month^{-1}$ 2 years after planting (April 1994) and 31.3 plants ha^{-1} $month^{-1}$ at the end of the third year (April 1995). Currently the infection rate has reached 43 plants ha^{-1} $month^{-1}$.

In B93, the infection rate reached 5.39 plants ha^{-1} $month^{-1}$ at the end of year two (December 1994). In August 1995, the infection rate had reached 36 plants ha^{-1} $month^{-1}$. By August 1995, for a farm of 349 ha, a total of 104 353 plants had been infected. This is equivalent to about 52 ha or 15% of the production area.

The pathogen

Race identification

In Malaysia, very little research and development work has been carried out with respect to *Foc* in banana. As recently as 1991 the *Foc* that had attacked

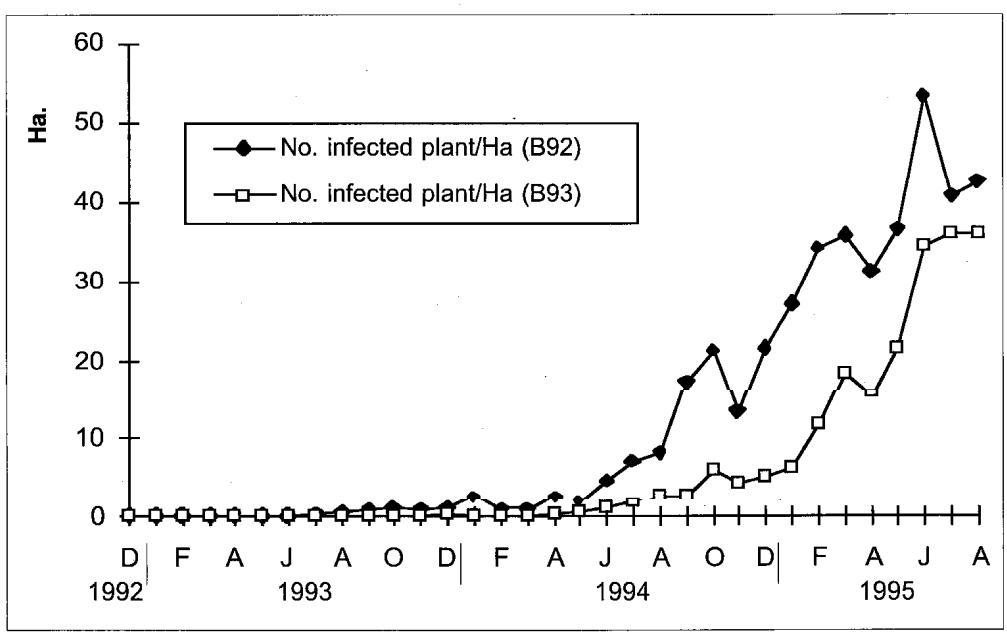

Fig 1. Monthly infection rate of *Foc* in Kumlim Montel Farm

Table 1. Monthly distribution of *Foc*-infected plants in Kulim Montal Farm.

Year	Month	Number of infected plants		
		B92[1]	B93	Total
1992	December	5	0	5
1993	January	8	0	8
	February	2	0	2
	March	1	0	1
	April	5	0	5
	May	19	0	19
	June	9	0	9
	July	56	3	59
	August	80	0	80
	September	127	0	127
	October	154	5	159
	November	129	23	152
	December	179	26	205
		769	57	826
1994	January	423	10	433
	February	145	12	157
	March	131	13	144
	April	440	36	476
	May	335	83	418
	June	747	213	960
	July	1139	355	1494
	August	1286	526	1812
	September	2778	549	3327
	October	3415	1152	4567
	November	2112	851	2963
	December	3457	1018	4475
		19408	4818	21226
1995	January	4354	1206	5560
	February	5459	2203	7662
	March	5725	3462	9187
	April	5008	2911	7919
	May	5848	4082	9930
	June	8557	6537	15094
	July	6531	6791	13322
	August	6831	6791	13622
		48313	33983	82296
Total		**65495**	**38858**	**104353**

[1] B92: planted in 1992; B93: planted in 1993.

Table 2. Monthly infected rate of *Foc* in Kulim Montal Farm.

		Number of infected plants/ha^{-1}/months^{-1}		
Year	**Month**	**B92**[1]	**B93**	**Total**
1992	December	0.03	0.00	0.01
1993	January	0.05	0.00	0.02
	February	0.01	0.00	0.01
	March	0.01	0.00	0.00
	April	0.03	0.00	0.01
	May	0.12	0.00	0.05
	June	0.06	0.00	0.03
	July	0.35	0.02	0.17
	August	0.50	0.00	0.23
	September	0.79	0.00	0.36
	October	0.96	0.03	0.46
	November	0.81	0.12	0.44
	December	1.12	0.14	0.59
		4.81	0.31	2.37
1994	January	2.64	0.05	1.24
	February	0.91	0.06	0.45
	March	0.82	0.07	0.41
	April	2.75	0.19	1.36
	May	2.09	0.44	1.20
	June	4.67	1.13	2.75
	July	7.12	1.88	4.28
	August	8.04	2.78	5.19
	September	17.36	2.90	9.53
	October	21.34	6.10	13.09
	November	13.20	4.50	8.49
	December	21.61	5.39	12.82
		102.55	25.49	60.81
1995	January	27.21	6.38	15.93
	February	34.21	11.66	21.95
	March	35.78	18.32	26.32
	April	31.30	15.40	22.69
	May	36.55	21.60	28.45
	June	53.48	34.59	43.25
	July	40.82	35.93	38.17
	August	42.69	35.93	39.03
		302.04	179.81	235.79
Total		**409.43**	**205.61**	**298.98**

[1] B92: planted in 1992; B93: planted in 1993.

the commonly grown banana cultivars such as Pisang Mas (AA), Pisang Berangan (AAA), Pisang Rastali (AAB) and Pisang Embun (AAA) was thought to be race 1 (Yacob bin Doon 1991). The commercial planting of Cavendish in JTP/KMF was thought to be the correct strategy as Cavendish banana is resistant to race 1. With the detection and subsequent outbreak of *Foc* in both JTP and KMF, this assumption was proved incorrect.

Recent observations, carried out using popular local cultivars such as Pisang Mas (AA), Pisang Berangan (AAA), Pisang Embun (AAA) and Pisang Rastali (AAB) in KMF, showed that these cultivars were susceptible to *Foc*.

Vegetative compatibility analysis of isolates from Malaysia confirmed the existence of VCGs 0120, 0123 and 01213. However, some isolates cannot be placed in a current VCGs (Pegg *et al.* 1993). Isolates from KMF were placed under VCG 01213 and VCG 01216 (Moore, pers. comm.). Isolates from KMF cultured on modified Komada's medium (K2 medium) formed laciniate colonies very similar to the race 4 isolates from Taiwan (Hwang, pers. comm.). It is therefore most probable that the isolates of *Foc* present in KMF are race 4 or race 4-like isolates.

Symptoms and development of the disease

Infection is characterized by yellowing of leaves beginning along leaf margins and advancing towards the midribs. Brown spots of various shapes and sizes appear on the yellow leaves and petioles turn brown and buckle. Eventually, the whole drooping leaf turns dark brown. Yellowing and buckling progress from older to younger leaves, and the entire plant dies. Frequently, the pseudostems split longitudinally just above soil level. Occasionally, the outer leaf sheaths of infected plants separate from the pseudostems and collapse and the trees appear thinner than uninfected ones.

Measures for disease control

Cultural methods

During the initial stage of the disease development where only two localized areas in B92 were infected, containment of the infected sites was attempted. The following measures were taken:

- Total removal and *in situ* burning of the infected and buffer plant parts (leaves, pseudostems, corms and roots).
- Drenching of infected sites with 10% Formalin at 3 L/m^2.
- Fumigating of infected sites with Basamid (98% a.i. dazomet) at 50 g product/m^3.
- Liming of the infected sites.
- Protecting neighbouring healthy plants with fungicide soil drench

All the above cultural methods attempted were not effective in the control or containment of the disease.

The current cultural practice applied by farmers consists of bimonthly inspection of all plants. Once a diseased plant is detected, it is marked and injected with a herbicide (glyphosate). This ensures that the diseased plants die and dry up as soon as possible. Once this happens, the diseased plant is burned *in situ*. Removal and chopping of the infected plant tissue is not encouraged as this operation would spread the inoculum onto the soil. However, this exercise will not contain or control the spread of the disease.

Disease-resistant varieties

The best method for controlling *Foc* is to plant resistant varieties. Following the success of screening for resistance to *Foc* using meristem culture plantlets in Taiwan (Hwang and Ko 1988), KMF initiated the screening of surviving individuals from badly infested diseased fields for possible resistant/tolerant cultivars. Testing and screening of new banana cultivars will also be carried out. Results from the above trials are currently pending.

Discussion and conclusion

With the detection and outbreak of *Foc* in Cavendish banana in KMF and JTP, it is therefore most probable that race 4 or race 4-like isolates of the fungus exist in Malaysia. These isolates also attack the commonly grown banana cultivars. There are no effective cultural and chemical methods of controlling the disease. The rate of infection, which increases geometrically, would make any commercial farm uneconomical in 4-5 years from planting. No replanting in the infected points could be carried out as the young plants were infected 4-6 months after planting. Therefore, it is necessary to develop resistant cultivars to replace the present susceptible cultivars.

There is also an urgent need to understand the variability, VCG, races and other pathogen attributes of *Foc* in Malaysia. The pathogenic potential of isolates present in Malaysia should be investigated. It is hoped that the International *Musa* Testing Programme (IMTP) will contribute to this objective.

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