Pertanika 8(3), 331 – 336 (1985)

Soil Fusaria from Oil Palm Habitats in Malaysia

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Key words: *Fusarium;* soil; oil palm.

ABSTRAK

Spesies Fusarium *telah diasingkan dari 22 tempat sampel di empat buah ladang kelapa sawit yang terletak di kawasan berlainan di Semenanjung Malaysia. Lapan spesies dan dua varieti bagi* Fusarium *viz,* F. solani, F. oxysporum, F. oxysporum *var.* redolens, F. semitectum, F. moniliforme, F. moniliforme *var.* subglutinans, F. equiseti, F. longipes, F. lateritium *dan* F. heterosporum *telah diasingkan. Daripada spesies tersebut,* F. solani *dan* F. oxysporum *adalah yang terbanyak dan diikuti oleh* F. semitectum *dan* F. moniliforme. *Lima spesies dan 2 varieti* Fusarium *yang lain jarang berlaku. Umumnya tanah dari kawasan yang ditumbuhi oleh palma muda mempunyai lebih banyak varieti spesies* Fusarium *jika dibandingkan dengan tanah dari kawasan palma matang dan tua. Tanah rizosfera mengandungi lebih banyak varieti spesies* Fusarium *daripada tanah* avenue *palma (tanah yang bukan rizosfera).*

ABSTRACT

Fusarium *species were isolated from 22 sampling sites in 4 oil palm plantations located in different regions of Peninsular Malaysia using Peptone-PCNB medium. Eight species and two varieties of* Fusarium *viz.,* F. solani, F. oxysporum, F. oxysporum *var.* redolens, F. semitectum, F. moniliforme, F. moniliforme *var.* subglutinans, F. equiseti, F. longipes, F. lateritium *and* F. heterosporum *were isolated. Among these,* F. solani *and* F. oxysporum *were the most prevalent species followed by* F. semitectum *and* F. moniliforme. *The other 5 species and 2 varieties of* Fusarium *were of sporadic occurrence. Generally, soils from areas with young palms had larger number and greater variety of* Fusarium *species when compared to soils from mature and old palm areas. The rhizosphere soil contained a greater variety of* Fusarium *species than soils in the avenue of palms (non-rhizosphere soil).*

INTRODUCTION

Distribution of *Fusarium* species in the soils of cultivated and uncultivated habitats has been extensively studied and well documented in the temperate regions of the world. In contrast, such studies have not been extensive in tropical regions. Investigations on soil-borne fusaria in Malaysia have been attempted only recently (Lim, 1972; Varghese, 1972; Lim & Varghese, 1977). There was also one study from the neighbouring country of Singapore (Lim & Chew, 1970). The present study was initiated to determine the relative abundance and distribution of *Fusarium* species in soils of oil palm habitats in Peninsular Malaysia.

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MATERIALS AND METHODS

Four locations, three on the west coast and one on the east coast of Peninsular Malaysia were selected as sampling sites. The three on the west coast were Kelang, Teluk Intan and Layang-Layang. The one in the east coast was in Sungei Tong, Trengganu.

At each location, the sampling sites were chosen according to the following categories:

(a) Area with young palms — 1 – 2 years old.

(b) Area with mature palms — 7 – 10 years old.

(c) Area with old palms — over 25 years old.

However in Sungei Tong, only young and mature palm areas could be sampled as there are no old plantings in the east coast. For each category of sampling site, soil was collected in the rhizosphere zone of palms (0.3 m from the base of palm) and from the avenues of palms (between planting rows).

The sampling method used in each of the areas was adapted from the method given by Varghese (1967) for sampling soil microflora in oil palm habitats. For each sampling site, one set of 15 samples was taken from the rhizosphere zone of palms and another set of 15 samples from the avenues. A modified soil core sampler (Varghese, 1972) was used for taking soil samples to a depth of 30 cm as previous studies by Lim & Varghese (1977) had shown that *Fusarium* species were mostly distributed within a depth of 0 – 30.5 cm. The soil samples taken from the rhizospheres and the avenues of palms at each sampling site were separately bulked and then stored in clean plastic bags in a cold room at 4°C. The soil was plated within 24 hours of storage. Before plating, the bulked samples were mixed thoroughly and passed through a 20-mesh (2000 μm) sieve to remove coarse organic matter or gravel present. The sampling was carried out during the dry season.

The soils of Layang-Layang and Sungei Tong are sandy clay loam (70% sand and 30% clay and silt) from igneous parent material, and those from Kelang and Teluk Intan are silty clay (10% sand and 90% clay and silt) from marine coastal alluvium. The pH of the soil ranged from 3.8 – 5.1 and the organic content from 8.1% in soils from avenues of mature palms in Layang-Layang to 17.2% in rhizosphere soils of young palms in Teluk Intan. Moisture content ranged from 19.8 – 33.3%. Details of physio-chemical characteristics of the soils are given by Ho (1984).

The dilution plate method (Nash & Snyder, 1962) with modified peptone-PCNB agar (Papavizas, 1967) amended with 200 ppm of a surfactant (Tween 20) as a selective medium was used for isolation and enumeration of *Fusarium* species from the soil. A dilution of 1 : 500 was used throughout except for some samples which were repeated at 1 : 1000 when counts were too high to be reliable at 1 : 500 dilution. One-ml aliquots were transferred by means of a 1 ml pipette to the agar plates. Eight replicates were used. The plates were incubated at room temperature (27 ± 2°C) for the first 2 or 3 days in diffuse daylight to inhibit the development of 'phycomycete' species. The plates were then transferred to an incubator at 27 ± 1°C and the colonies were counted after 6 – 7 days incubation and identified to species according to the classification of Booth (1971).

RESULTS

Quantitative estimation of the total *Fusarium* population in the soils from the various sampling sites is given in Table 1. Generally, the silty-clay soil from Kelang and Teluk Intan contained a larger population of *Fusarium* than sandy clay soil from Layang-Layang and Sungei Tong. In all the locations, the soils from young palm areas contained a significantly ($P \leqslant 0.05$) larger number of *Fusarium* propagules than soils from the mature or old palm areas. The population of *Fusarium* was also significantly ($P \leqslant 0.05$) larger in soils from the rhizospheres of palms than soils from the avenues of palms.

A total of 8 species and 2 varieties of *Fusarium* was isolated from the sampling sites.

TABLE 1
Quantitative estimation of the total population of *Fusarium* species in oil palm habitat

Location		Mean number (propagules/g dry soil) of *Fusarium* species
Kelang	silty-clay soil	5656 [a*]
Teluk Intan	silty-clay soil	5208 [a]
Layang-Layang	sandy-clay soil	3238 [b]
Sungei Tong	sandy-clay soil	2409 [b]
Young palm areas		6136 [a*]
Mature palm areas		2819 [b]
Old palm areas		3763 [b]
Rhizospheres of palms		5946 [a*]
Avenue of palms		2619 [b]

*Mean values with different letters are significantly different at P = 0.05 as determined by Duncan New Multiple Range Test.

These were *Fusarium solani* (Mart.) Sacc., *Fusarium oxysporum* Schlecht, *Fusarium oxysporum* var. *redolens* (Wollenw.) Gordon, *Fusarium semitectum* Berk. & Rav., *Fusarium moniliforme* Sheldon, *Fusarium moniliforme* var. *subglutinans* Wollenw. & Reink., *Fusarium longipes* Wollenw. & Reink., *Fusarium equiseti* (Corda) Sacc., *Fusarium heterosporum* Nees ex Fr., and *Fusarium lateritium* Nees, Link. The quantitative estimation for each species is given in Table 2.

Fusarium solani was the most prevalent and abundant species present. *Fusarium oxysporum* was also widely distributed being present in all soils examined but generally it occurred in fewer numbers than *F. solani*. The next most prevalent species was *Fusarium semitectum*. It was isolated from 14 of the 22 sites sampled. The other five species and two varieties of *Fusarium* were unevenly distributed and occurred infrequently in low numbers in the soils, mainly in the rhizosphere of palms. Among these, *F. longipes* occurred in 4 sites sampled, *F. moniliforme* and *F. lateritium* in three and *F. equiseti* was present in two sites, both of which were in Kelang. *F. oxysporum* var. *redolens* was also obtained in two sites from Teluk Intan. *Fusarium heterosporum* and *F. moniliforme* var. *subglutinans* were isolated only once — in Layang-Layang and Kelang respectively.

DISCUSSION

The results of the present study showed that soil under oil palm cultivation contained a relatively wide spectrum of *Fusarium* species. Generally, populations were higher in the rhizosphere soils than in soils from avenues of palms. The increase in *Fusarium* population in rhizosphere soils is not surprising since in the root zones of the palms there is an increase in nutrient supply arising from root exudates, sloughed off tissues and dying and decaying root fragments. Various amino acids and sugars from these sources provide the requirements necessary for germination and growth of fungal propagules.

It is interesting to note that soils from young palm areas generally contained a larger number of *Fusarium* propagules and species than those from areas of mature and old palms. This could

TABLE 2
Population of each *Fusarium* species in oil palm soils

Location	Palm age	Sample origin	Number of propagules/g dry soil of *Fusarium* species and varieties									
			solani	*oxysporum*	*semitectum*	*moniliforme*	*equiseti*	*longipes*	*lateritium*	*heterosporum*	*moniliforme* var. *subglutinans*	*oxysporum* var. *redolens*
Kelang	Young	R [a]	6510	2883	183	—	186	279	—	—	93	—
		NR	5439	1383	184	—	—	92	—	—	—	—
	Mature	R	3033	919	92	—	552	—	—	—	—	—
		NR	1462	548	— [b]	—	—	—	—	—	—	—
	Old	R	4982	2808	181	—	—	362	—	—	—	—
		NR	1183	546	—	—	—	—	—	—	—	—
Teluk Intan	Young	R	5622	4498	937	1312	—	—	187	—	—	375
		NR	4391	1121	93	—	—	—	—	—	—	—
	Mature	R	2110	967	440	—	—	88	—	—	—	—
		NR	954	780	—	—	—	—	—	—	—	—
	Old	R	2220	3019	—	—	—	—	—	—	—	178
		NR	979	979	—	—	—	—	—	—	—	—
Layang-Layang	Young	R	2856	1877	326	326	—	—	82	163	—	—
		NR	1409	1326	—	—	—	—	83	—	—	—
	Mature	R	3508	957	80	—	—	—	—	—	—	—
		NR	729	567	81	—	—	—	—	—	—	—
	Old	R	2144	794	318	—	—	—	—	—	—	—
		NR	942	549	393	—	—	—	—	—	—	—
Sungei Tong	Young	R	2277	1021	157	—	—	—	—	—	—	—
		NR	1084	464	—	—	—	—	—	—	—	—
	Mature	R	1829	1352	159	159	—	—	—	—	—	—
		NR	710	474	—	—	—	—	—	—	—	—

a = R, rhizosphere of palm; NR, non-rhizosphere soil between avenues of palms.
b = — fungus not detected at dilution used.

be the result of factors such as an increase in the organic and mineral content of the soil through frequent application of mineral fertilizers and organic deposition from leguminous cover crops planted throughout the immature period of the palms. Mineral fertilizers are usually applied 5 – 6 times a year to young palm areas whereas in the mature and old palm areas application is limited to 2 – 3 times a year. The planting of mixed leguminous cover *(Pueraria phaseoloides, Calopogonium caeruleum, Centrosema pubescens* and *Calopogonium mucunoides)* during the immature stage of oil palms is a common practice in oil palm cultivation in Malaysia. The leguminous cover fixes and returns large quantities of nitrogen and organic matter besides providing other benefits such as forming a green manure, preventing soil erosion, conserving soil moisture and humus, improving soil structure and aeration and reducing weed competition. In contrast, in the avenues of mature and old palms, there is no legume cover except natural vegetation which consists of grasses *(Axonopus compressus, Paspalum conjugatum), Caladium* spp. and ferns *(Nephrolepis biserrata, Gleichenia linearis* and *Lygodium* spp.). Soil analysis confirmed that the organic content of soils from young palm areas was generally higher than that of soils from mature or old palm areas (Ho, 1984). Undoubtedly, better soil structure, organic content and fertility of the young palm areas were more conducive to greater activity of *Fusarium* species, resulting in significantly larger populations of soil fusaria. It is interesting to note that the population of *F. solani,* in particular, was significantly higher in soils of young palm areas with leguminous cover.

There was an association between soil type and population of *Fusarium. Fusarium* species were isolated more frequently from the silty clay soils (Kelang and Teluk Intan) than from the sandy clay soils (Layang-Layang and Sungei Tong). These results agree with those of Lim (1971) who reported a higher population of fusaria in silty clay than in sandy soil. Stover (1954) also found that clay loam soil maintained the highest population of *F. oxysporum* f. sp. *cubense* and sand the lowest and that the addition of sand reduced the ability of the clay loam to support a larger *Fusarium* population.

F. solani was the most abundant species in all the soils studied. Previous surveys in Singapore (Lim & Chew, 1970) and in Malaysia (Lim, 1972; Lim & Varghese, 1977) had also indicated *F. solani* to be the dominant species in both uncultivated soils and cultivated soils under a variety of crops.

The population of *F. oxysporum* in oil palm soils was slightly smaller than that of *F. solani* but *F. oxysporum* was just as widely distributed. Previous investigations in Malaysia showed similar results — *F. oxysporum* being the second most prevalent species in most cultivated soils (Lim & Varghese, 1977). In Singapore soils, *F. oxysporum* appeared to be the third most abundant species isolated (Lim & Chew, 1970). Unlike *F. solani, F. oxysporum* has been found to be as abundant in pasture and cultivated soils of the temperate regions (McKenzie & Taylor, 1983) as it is in the tropics. In contrast to its very frequent occurrence in cultivated soils, *F. oxysporum* seems to be less abundant in forest soils (Park, 1963; Lim, 1971; Aderungboye, 1975).

The isolation of *F. semitectum* is a new record for soils of oil palm habitat in Malaysia, although Lim (1971) had recorded it in other habitats such as vegetable, banana and wet paddy areas. Booth (1971) and Domsch *et al.* (1980) reported that *F. semitectum* is extremely common in tropical and subtropical countries where it exists more often as a secondary invader of plant tissues than as a soil inhabitant.

The remaining five species and two varieties of *Fusarium* (viz. *F. moniliforme, F. moniliforme* var. *subglutinans, F. equiseti, F. longipes, F. heterosporum, F. lateritium* and *F. oxysporum* var *redolens*) showed sporadic occurrence in the oil palm soils. The occurrence of these species and varieties is a new record for oil palm habitats in Malaysia although Lim (1971) had recorded some of them from soils of other habitats. *F. heterosporum* and *F. oxysporum* var. *redolens* are recorded for the first time from

Malaysian soils. The latter is very widespread in soils of both temperate and subtropical regions (Gorden, 1956, Joffe *et al.*, 1974).

None of the *Fusarium* species collectively placed under the binomial *F. episphaeria* (Tode) Snyder & Hansen were detected in any of the oil palm soils examined in the present study although it was isolated by Lim & Chew (1970) and Lim (1971) in soils of uncultivated and perennial crop habitats including one oil palm area. Isolates of this species are frequently reported from colder regions. It is the most prevalent *Fusarium* species in grassland soils of Iceland (Kommedahl & Siggeirsson, 1973) and has been isolated from soils in Britain (Synder & Nash, 1968; McKenzie & Taylor, 1983) California (Nash & Snyder, 1965) and Australia (Wearing & Burgess, 1977).

ACKNOWLEDGEMENTS

We thank Dr. C. Booth, Commonwealth Mycological Institute, Kew, England for confirming the identification of the *Fusarium* species.

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(Received 3 June, 1985)