ASSESSMENT OF THE SPATIAL AND TEMPORAL PROLIFERATION OF UPPER STEM ROT DISEASE IN OIL PALM PLANTATIONS (*ELAEIS GUINEENSIS*) IN THE KUDAT REGION, SABAH.

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DECLARATION

I declare that this dissertation is my original work except for quotations and summary that has been cited in reference.

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PENILAIAN RUANGAN DAN MASA TERHADAP PERTUMBUHAN PENYAKIT REPUT BATANG ATAS DALAM LADANG KELAPA SAWIT (*ELAEIS GUINEENSIS*) DI KAWASAN KUDAT, SABAH

ABSTRAK

Kajian tersebut dijalankan untuk menilai variasi berkenaan dengan ruang dan masa demi meramal pertumbuhan penyakit reput batang atas (RBA) di kawasan Kudat, Sabah. Peringkat pertumbuhan penyakit RBA direkodkan melalui visual mengikut 10 kategori dan dilaksanakan di Blok 3S dan 4S dalam estat Langkong (N06°30'39.8", E116°42'30.5") dari tahun 1997 sehingga 2004. Data akan dianalisis melalui *postmap* (Surfer Version 7 software package) untuk menyiasat corak pertumbuhan penyakit tersebut utama dan kawasan yang paling berkemungkinan bagi penyakit RBA (Crimestat software package). Blok 3S dan 4S menduduki sebanyak 24% daripada perhubungan berkenaan dengan ruang dalam eksperimen pengawasan *semi-variogram* walaupun mereka menunjukkan perhubungan secara ruangan yang lemah. Terdapat hubungan yang rapat antara peristiwa jasad berbuah *Ganoderma* dengan peristiwa pokok kelapa sawit yang tumbang pada tahun berturut-turutan. Sebaliknya, peristiwa batang atas patah dan peristiwa pelepah patah tidak wujud hubungan malahan kedua-dua peristiwa tersebut tidak wujud hubungan dengan peristiwa jasad berbuah *Ganoderma* dengan peristiwa pokok kelapa sawit yang tumbang. Hasil daripada kajian tersebut, dapat disimpulkan bahawa jasad berbuah *Ganoderma* bukan punca yang menyebabkan penyakit RBA dalam ladang kelapa sawit di estat Langkong. Pengawasan melalui jangka masa panjang terhadap peringkat-peringkat penyakit RBA adalah amat diperlukan untuk mengatasi masalah pertumbuhan penyakit kulat *Ganoderma* berkenaan dengan masa.

ABSTRACT

This study was initiated to assess the spatial and temporal variation to predict the distribution of the Upper Stem Rot (USR) disease in Kudat region, Sabah. The USR disease status was visually recorded according to 10 stages and carried out in Block 3S and 4S within the Langkong estate (N06°30'39.8", E116°42'30.5") from 1997 until 2004. Data analyzed through employing post map (Surfer Version 7 software package) to investigate pattern of preferential distribution and hotspots of USR disease incidences (Crimestat software package). Block 3S and 4S appear a total of 24% of spatial relationship in experimental semi-variogram modelling although they represented that weak spatial dependence existed between them. There has a close relationship in Block 3S and 4S between *Ganoderma* fruiting bodies and fallen palm incidences in the following year by chronological events. On the other hand, upper stem fracture and skirting incidences did not showed any relationship, and between them with *Ganoderma* fruiting bodies and fallen palm incidences. From this present result, concluded that upper stem rot incidence was not caused by *Ganoderma* fruiting bodies. Long-term monitoring of disease stages of USR is required to resolve temporal proliferation of the *Ganoderma* disease in both blocks.

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^{o}	Degree
h	Vector
θ	Direction
C_0	Nugget effect
C_1	Spatial dependence
C	Sill
a	Range
NR	The strength of the spatial dependence

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CHAPTER 1

INTRODUCTION

1.1 Oil Palm in Malaysia

Palm oil has become one of the main contributors to Malaysia economy as a result of the Government's Crop Diversification Programme in the 1960s (Fuad *et al.*, 1999). Malaysia is the world's largest producer of oil palm and exports almost all its production (Fuad *et al.*, 1999). The annual export revenue in 2003 amounted to RM 27.7 billion and oil palm contributed 7.3 % to the national GDP (Department of Statistics Malaysia, 2003). However, intense oil palm monoculture has resulted in an environmental imbalance causing numerous pathogenic diseases, pests and physiological disorders (Turner, 1981).

1.2 Oil Palm Stem Rot

One of the most important diseases in oil palm is currently basal stem rot (BSR) in Malaysia (Turner, 1981 and Singh, 1991). *Ganoderma boninense*, the pathogen causing basal stem rot and upper stem rot (USR) disease of oil palm remain the most significant constraint to sustainable oil palm production in South East Asia with numerous yield losses through direct loss of the stand, reduced yield of diseases palms and requirement for earlier replanting (Flood *et al.*, 2002).

The ratio of USR to BSR in different estates ranges from 1:10 to 1:1 and in some fields the incidence of USR exceeds that of BSR (Hasan *et al.*, 2004). In some commercial field in Lonsum estates situated in Indonesia, the incidence of USR is higher than incidence of BSR (Flood *et al.*, 2002) meanwhile the incidences of USR have shown as high as 5 % in some Malaysia fields (Turner and Gillbanks, 1974). In the Kudat region of Sabah, the incidence of USR is also higher than incidence of BSR (field observation) and for 30 years old palm tree estates, 5 % of the total area must be replanted (Hoong, personal communication, Borneo Samudera Sdn. Bhd.).

1.3 Current Status

At present, control strategies are only aimed at delaying the progress of infection and prolonging the productive life of the palm (Ariffin *et al.*, 1989b; Ariffin and Idris, 1991a; Ariffin *et al.*, 2000; Flood *et al.*, 2000; George *et al.*, 1996; George *et al.*, 2000; Idris *et al.*, 2002; Idris and Ariffin, 2003; Joseph, 2000; Khairudin, 1990 and 1993; Lim et al., 1993; Marshall and Hunt, 2004; Nazeeb *et al.*, 2000; Rao *et al.*, 2003; Sariah and Zakaria, 2000; Singh, 1991; Soepena *et al.*, 2000). In addition, although treatment of early stages of disease can be successful, by this time when the fruiting body of *G. boninence* appears, it is discovered that at least one-half of the stem part has been rot and cannot be treated anymore (Paulinus, personal communication, Borneo Samudera Sdn. Bhd).

The studies of Miller *et al.* (1999) using somatic incompatibility and mitochondrial DNA profiling of isolates taken from palms revealed that the considerable heterogeneity with different genotypes even occurring infected palm. Although molecular methods have been developed to detect the fungus in the palm tree, those methods are not applicable for a broad scale of field. Thus, prediction of high-risk areas within a plantation, which can be monitored and treated within the framework of precision farming, is needed immediately.

1.4 Geostatistics

Geostatistics is based on the theory of regionalized variables developed by Matheron in the late 1950 on the basis of empirical relations, which Krige (1950), D.G., a South African geologist, applied for predicting the gold reserves in placers (Armstrong, 1998). Geostatistics focuses on the analysis of spatially distributed variables and the prediction or estimation of values at unsampled locations.

Nelson *et al.* (1999) stated that regional surface maps are appropriate when a variable (pathogen propagule density, disease incidence, insect vector abundance, etc) exhibits positive spatial autocorrelation beyond the boundary of a single field. Nowadays, it has been used in plant pathology to analyze the spatial distribution of plant disease epidemics, mainly at plot or field scales (Kocks *et al.*, 1998; Van de Lande and Zadoks, 1999; Castrignanò *et al*, 2000; Pethybridge and Madden, 2003; Xu and Madden, 2004).

1.5 Aims of this Study

This study was initiated to assess the spatial and temporal variation in order to predict the distribution and proliferation of the disease.

To achieve the above objective following tasks were carried out:

1. Variography of the spatial distribution of USR disease.

2. Analysis of the temporal proliferation of USR disease within eight years.

CHAPTER 2

LITERATURE REVIEW

This chapter was divided into two main parts that upper stem rot disease in oil palm and spatial variability analyses.

2.1 Upper Stem Rot disease in Oil Palm

Upper stem rot is commonly found on diseased palms symptoms similar to spear rot, bud rot, bunch rot and basal stem rot caused by root diseases (Ng, 1972). Lower leaves first become yellow and die from the tip to the base. This condition progresses to the middle of the crown and finally affected the spear leaves. The stem tissues will show a brown rot while the roots of the palm are not affected.

Infection of oil palm by *Fomes noxius* (also known as "*Phellinus noxius*") to produce symptoms of USR disease has been known in Peninsular Malaysia and Sabah, Indonesia and West Africa (Turner, 1969). Usually, USR affected palms died. Both of fungus (*Fomes noxius* and *Ganoderma boninense*) are also responsible for death to a majority of young palms planted in areas where a former rubber stand was heavily infected with brown root disease (Turner, 1981).

The disease is expected to spread from infected debris (through root contact or mycelial spread) would produce a homogenous pathogen population in the infected oil palm as can be seen with other wood rotting fungi – *Heterobasidion annosum* (Stenlid, 1985 cited in Hasan and Flood, 2003) or *Phellinus noxius* (Hattori *et al*., 1996 cited in Hasan and Flood, 2003) where one clone of the pathogen can extend over several metres.

2.1.1 Causal agent

Reported earlier by Turner (1981) stated that *Fomes noxius* is the primary causal factor of upper stem rot disease. He also stated that fructification of *F. noxius* only develops on frond butts of palms which are affected by an extensive stem rot. However, *F. noxius* was not isolated from these rotten stem tissue samples. Turner (1969) showed that sporophores of *Ganoderma* spp. are also found on lesions, but it is believed that these are formed as the result of secondary colonisation of tissues destroyed primarily by *F. noxius.* Thompson (1931) cited in Flood *et al.* (2002) also suggested that *Ganoderma* spores which are responsible for USR disease are usually associated with *F. noxius* species but due to inability of researchers to artificially inoculate with *Ganoderma* in these diseased palms; hence this theory lost vogue.

A total of 75 isolates of *Ganoderma* were collecting from 21 locations in Peninsular Malaysia and one in Sabah (Turner, 1981). Based on *in vitro*, morphological studies, *G. boninense* and *G. zonatum* were associated with the rotten upper stem. Flood *et al.* (2002) stated that USR are always causing discrete lesions originate from the axils of the frond base and spread in successive wave of rot, each delimited by the brown or black line of *Ganoderma* infections.

Ariffin *et al.* (1989a) revealed that the black line observed in the stem of oil palm infected with *G. boninense* is caused by a single mycelium and thus emphasizes the fungal origin of its formation. As presence of fungal hyphae almost exclusively on one side of the black line precludes the possibility of a dual infection involving another fungus and clearly indicates that *G. boninense* is the sole fungus present.

Another study on the effects of injured and non-injured roots of oil palm on the infection by *G. boninense* was carried out by Malaysian Palm Oil Board (MPOB) in 2001. This study indicated that heavily injured roots influenced the speed of *G. boninense* infection in oil palm. The rate of the speed of *G. boninense* infection was between 1.62 to 2.12 cm month^{-1}, with the average being 1.83 cm month^{-1} (MPOB, 2001).

a. *Ganoderma boninense*

The fungus belongs to the true fungi phylum, Eumycophyta (known as Basidiomycota); derived from Basidiomycetes class, with the subclass being Holobasidiomycetidae. The order and family of *G. boninense* is Aphyllophorales (known as Polyporales) and Ganodermataceae respectively (Svrček, 1983). The larger basidiomycetes which bear basiodiospores are the familiar encrustations, brackets, toadstools and similar fructifications found on decaying timber are fruiting bodies

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