

Experiences in Peat Development for Oil Palm Planting in the MPOB Research Station at Sessang, Sarawak

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ABSTRACT

The rapid expansion of the oil palm industry and the depletion of prime land for oil palm cultivation have caused planters to resort to the marginal areas such as peat. Peatland with an area totalling approximately 2.6 million hectares is considered a problematic soil in Malaysia, but has potential for oil palm cultivation. The poor inherent physical properties of peat such as low bulk density, high water-table and rapid subsidence rate make its development for oil palm cultivation difficult and costly as compared to mineral soils. Through research and development carried out by various research institutions including the Malaysian Palm Oil Board (MPOB), planting of oil palm on drained peat has been successful and oil palm yield on peat is comparable to those from mineral soils. Various aspects of work or disciplines have been covered especially on land preparation techniques, drainage and water management, planting density and fertilizer requirements. The adoption of the results obtained over time has resulted in the better performance of oil palm especially on deep peat. From recent achievements, oil palm yields on peat are equal if not better than those from some of the mineral soils. This article discusses MPOB's experiences in planting oil palm on peat at the MPOB Research Station at Sessang, Sarawak.

ABSTRAK

Kekurangan tanah yang sesuai serta kepesatan pembangunan industri sawit telah menyebabkan usaha penanaman sawit di tanah marginal seperti tanah gambut. Di Malaysia, tanah gambut dengan keluasan hampir 2.6 juta hektar merupakan tanah bermasalah tetapi berpotensi untuk penanaman sawit. Ciri-ciri fizikal tanah gambut seperti kepadatan pukal yang rendah, paras air tinggi dan susutan tanah menyebabkan usaha penanaman sawit menjadi sukar dan memerlukan perbelanjaan yang tinggi berbanding dengan penanaman di tanah mineral. Hasil penyelidikan yang dijalankan oleh

pelbagai pihak termasuk Lembaga Minyak Sawit Malaysia (MPOB) telah berjaya meningkatkan pengeluaran hasil sawit di tanah gambut ke tahap setanding dengan di tanah mineral. Kejayaan penanaman sawit di tanah gambut, khususnya gambut dalam sangat bergantung pada tahap pelaksanaan teknologi yang diperkenalkan, terutama dari aspek kaedah penyediaan kawasan, teknik dan jarak penanaman, pengurusan air serta pembajaan sawit. Artikel ini membincang pengalaman MPOB dalam usaha penanaman sawit di tanah gambut di Stesen Penyelidikan MPOB Sessang, Sarawak.

Keywords: peat soil property, oil palm yield, water management, leaning incidence, termite infestation.

INTRODUCTION

Peat is defined as an organic soil with a thickness of organic matter of more than 50 cm, mineral content not exceeding 35%, and covering an area of more than 1 ha. Based on the U.S. Department of Agriculture (USDA) Soil Taxonomy (Anon, 1975), peat is classified under the *Histosols* soil group. In Malaysia, different systems of soil classification are being used in the three regions (Peninsula, Sabah and Sarawak). In Sarawak, the peat soils are classified according to families based on the depth of the peat and the nature of the mineral substratum. Two major depth classes are differentiated: shallow peat, namely Mukah 1 and 2 for peat depths of 50-100 cm and 100-150 cm, respectively, and deep peat, namely Anderson 1, 2 and 3 for peat depths of 150-200 cm, 200-250 cm and more than 250 cm, respectively (Tie, 1982). The important properties of peat have been described and summarized by several researchers (Abdul Mutalib *et al.*, 1991; Abdul Jamil *et al.*, 1993).

Peatland with an area totalling approximately 2.6 million hectares is considered a major problem soil in Malaysia (Abdul Mutalib *et al.*, 1991). In Sarawak alone, peatland covers approximately 1.6 million hectares, or 13% of the total land area in the state (Teng, 2003). The rapid expansion of oil

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palm cultivation has resulted in the depletion of good mineral soils and suitable land. The largest extent of marginal soils with potential for oil palm planting is peat, and in this respect, Sarawak with nearly 63% of the total peatland in Malaysia has the greatest potential. The inherent physical and chemical properties of peat make its development for oil palm cultivation difficult and costly. Earlier attempts at planting oil palm on peat resulted in poor growth and yield performance. Much of this was due to a lack of understanding on how best to develop and manage peat soils.

Low soil bulk density, high water-table and the presence of a large quantity of plant biomass (even after land clearing) as well as peat subsidence are among the major physical properties of drained peat that need amelioration for successful cultivation of oil palm. Through research and development carried out mostly in Peninsular Malaysia by several researchers, some measure of success has been achieved in the planting of oil palm on peat soil (Gurmit *et al.*, 1986; 1987; Mohd Tayeb *et al.*, 1996; Lim, 2002; Mohd Tayeb, 2002; Gurmit, 2004). Although much research has been carried out, the available information for oil palm planting on peat under Sarawak environmental conditions is still limited. In this respect, MPOB (formerly known as PORIM) provides research and development (R&D) support with the opening of a peat research station at Sessang in Sarawak. The establishment of this peat station is to enhance R&D activities, with particular focus on oil palm planting on peat under Sarawak environments.

This article presents 15 years' experience in oil palm planting on peat at MPOB Research Station, Sessang in Sarawak, giving attention to land preparation, water management and FFB yield potential. Problems of peat subsidence and leaning palms as well as termite infestation are also reported and discussed.

MATERIALS AND METHODS

Characteristics of the Study Area

The study was carried out at MPOB's peat research station located at Sessang, Sarawak which has an area totalling of 1000 ha of peatland. The area was previously a secondary forest of mixed peat swamp. Initially the peat depths ranged from 100 to 400 cm, consisting of undecomposed plant biomass (*fibric* soil material), while the nature of the mineral subsoil below the peat layer was a non-sulphidic clay. Based on Sarawak Soil Classification (Tie, 1982), peat in the area was classified as *Epai* and *Anderson Series* for peat depths of 100-150 cm

(shallow peat) and more than 150 cm (deep peat), respectively. Between 1990 and 2007, the station received high rainfall averaging 3487 mm annually with occasional dry months (*Figure 1*).

Preliminary work to establish and set up the plantation began in the year 1991. The standard land clearing method, *i.e.* under-brushing and felling, burning, stacking and re-burning, was adopted (Mohd Tayeb, 2005). Mechanical compaction of the harvesting paths and planting rows was carried out during land preparation to provide better accessibility through increased soil bulk density. The drainage system consisted of field drains after every four planting rows, giving an intensity of 340 m ha⁻¹. Oil palm seedlings were planted using the 'hole-in-hole' planting technique (Hasnol *et al.*, 2007). The field development and maintenance works followed normal estate practices. All fertilizers were broadcasted in the weeded palm circles, and details of the annual rate of fertilizer application are given in *Table 1*.

Experimental Block

For the purpose of this article, three trials from the Agronomy and Fertilizer Group were selected as the study blocks, and a description of the each experimental block is summarized in *Table 2*. The three trials are as follows:

- Trial 1: planting density x NPK requirement of oil palm on shallow peat;
- Trial 2: evaluation of commercial DxP progenies in relation to land preparation technique and planting system on deep peat; and
- Trial 3: fertilizer requirement and performance of oil palm in relation to drainage intensity on deep peat.

Parameter Measurement

Pre-treatment soil sampling and analyses were carried out to determine the chemical properties of the peat. The soil chemical properties were analysed according to the standard procedures of the *MPOB Soil and Plant Analysis Manual* (Zulkifli and Masnon, 1993a, b). Soil N was determined by a macro-Kjeldahl method. Soil-extractable P was determined using the molybdenum blue method with Bray's No. 2 extractant. Soil exchangeable K, Ca and Mg were determined by the shaking method, where K was determined using a flame photometer, while Mg and Ca were determined using an atomic absorption spectrometer.

TABLE 1. TYPE AND RATE OF FERTILIZER APPLICATION

Palm age (year after planting)	Type of fertilizer	Rate of application (kg palm⁻¹ yr⁻¹)
0 (planting hole)	Phosphate rock	0.20
	Copper sulphate	0.015
	Zinc sulphate	0.015
	Limestone dust	0.50
1	Urea	0.50
	Phosphate rock	0.50
	Muriate of potash	1.50
	Copper sulphate	0.15
	Zinc sulphate	0.15
	Limestone dust	2.00
2	Urea	0.75
	Phosphate rock	0.60
	Muriate of potash	2.40
	Copper sulphate	0.20
	Zinc sulphate	0.20
	Borate 48	0.10
3	Urea	1.00
	Phosphate rock	1.00
	Muriate of potash	3.00
	Copper sulphate	0.20
	Zinc sulphate	0.20
4	Urea	1.25
	Phosphate rock	1.25
	Muriate of potash	3.60
	Borate 48	0.10
5	Urea	1.25
	Phosphate rock	1.25
	Muriate of potash	4.00
6 and above	Urea	1.25
	Phosphate rock	1.25
	Muriate of potash	5.00
	Borate 48*	0.10

Note: * Borate HGFB (high grade fertilizer borate) 48: application every alternate year.

Changes in peat characteristics, such as peat depth, degree of peat decomposition, subsidence and bulk density, were monitored and recorded over the period of 17 years after peat was drained. Field water-table was measured using the lysimeter method, and the data were summarized to monthly figures. FFB yields were obtained by carrying out palm-to-palm recording of bunch number and weight, commencing at 36 months after planting, and the data summarized to yearly figures. Census on the incidence of leaning palms and termite infestation were carried out at six-month intervals. The progress of leaning incidence was grouped into three categories (Figure 2):

Mild : palms leaning progressively with the leaning angle at more than 45° from the ground level, but the leaning did not

seriously affect palm growth and FFB production (A);
Severe : palms toppled or at a leaning angle less than 45° from the ground level, seriously affecting palm growth and yield and which took a long time to recover (B); and
Recovered: leaning palms erect again and recovered their normal fresh fruit bunch (FFB) production (C).

The data were kept and managed by a relational database for agronomy data systems (READA). Analysis of variance (ANOVA) and Duncan's Multiple Range Test (Duncan's Test) of the Statistical Analysis Systems (SAS™) software were used to analyse the data.

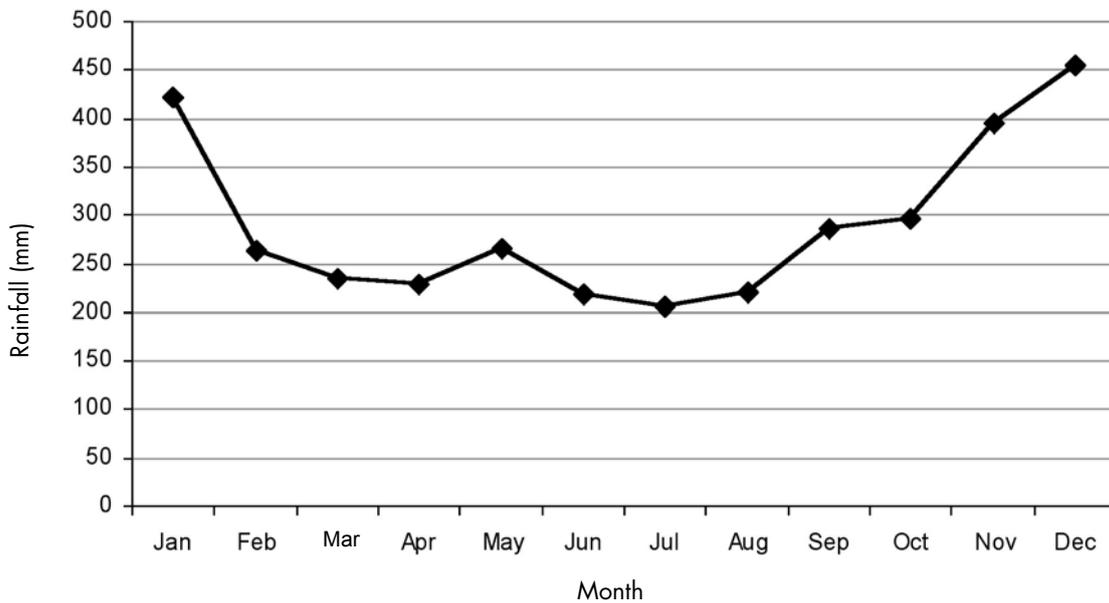


Figure 1. Mean average rainfall (1990-2007) in the MPOB Research Station at Sessang, Sarawak.

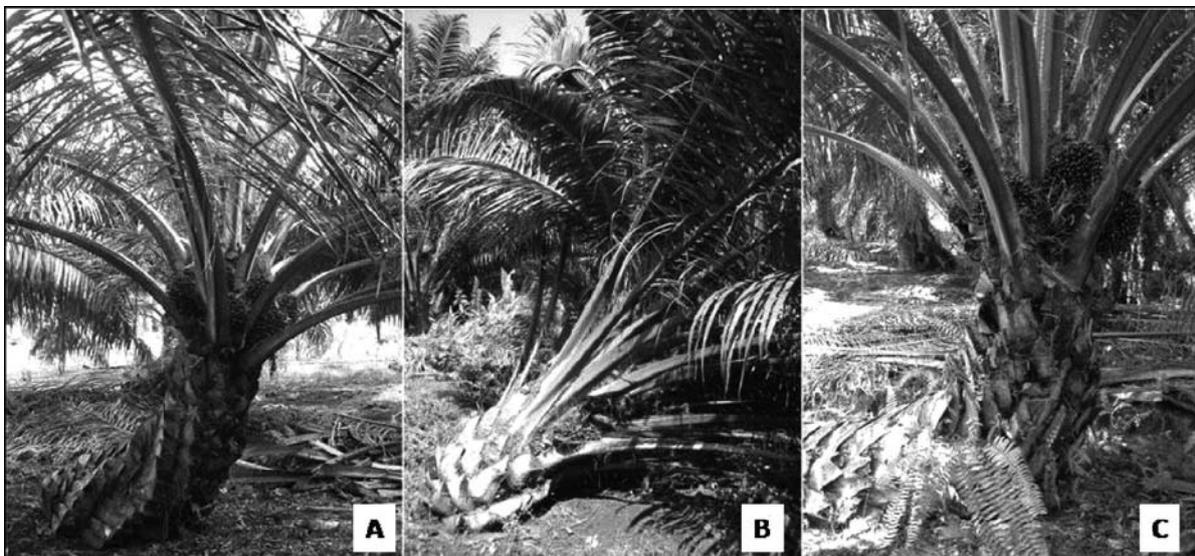


Figure 2. Categories of leaning palms - severe (A), mild (B) and recovered (C).

TABLE 2. SITE CHARACTERISTICS AND TRIAL DETAILS

Description/detail	Trial 1	Trial 2	Trial 3
Soil series	Epai	Anderson	Anderson
Peat depth (cm)	100-150	350-400	300-350
Date of planting	February 1994	November 1995	July 1997
Planting material	MPOB's DXP	Treatments: 4 commercial DXP planting materials	MPOB's DXP
Land preparation	Soil compaction	Treatments: 1. No soil compaction 2. 1 round of compaction 3. 2 rounds of compaction 3. 3 rounds of compaction	Soil compaction
Planting technique	'Hole-in-hole'	Treatments: 1. Normal hole 2. 'Hole-in-hole' 3. Slanting hole	Normal hole
Planting density	Treatments: 1. 120 palms ha ⁻¹ 2. 160 palms ha ⁻¹ 3. 200 palms ha ⁻¹	160 palms/ha ⁻¹	160 palms ha ⁻¹
Field drain intensity	Every 4 planting rows	Every 4 planting rows	Treatments: 1. Every 4 planting rows 2. Every 8 planting rows 3. No field drain
Area (ha)	30.0	85.0	38.0
Fertilizer application	Treatments: N (Urea) : 2 rates P (RP) : 3 rates K (MOP) : 3 rates Liming (LSD): 3 rates	Normal rate	Treatments: N (SOA) : 2 rates P (RP) : 3 rates K (MOP) : 3 rates Liming (LSD) : 3 rates

Note: SOA: sulphate of ammonia.

RP: rock phosphate.

MOP: muriate of potash.

LSD: limestone dust.

RESULTS AND DISCUSSION

Chemical Properties

In general, peat soils are considered to have very low nutrient contents, especially for phosphorus (P), potassium (K) and micronutrients. The total nitrogen (N) in peat is relatively high but the availability for plant uptake is rather low due to the high C:N ratio. In nature, peat is very acidic, and this is a serious limitation to oil palm growth and yield. The data on the initial chemical properties of peat in the study area are presented in *Table 3*. For

both the shallow and deep peats, the soil pH and organic carbon content had relatively insignificant differences, with average values of 3.45 and 24.68%, respectively. For the deep peat, total N was higher at 2.98% compared to 1.21% for the shallow peat, subsequently giving a lower C/N ratio for the deep peat. The concentration of available P was much higher in the shallow peat at 73.8 mg kg⁻¹ compared to 42.9 mg kg⁻¹ in the deep peat. The initial status of exchangeable K, Ca and Mg in the shallow peat was higher at 30%, 42% and 18%, respectively, compared to the status of these exchangeable cations in the deep peat.

TABLE 3. SUMMARY OF INITIAL CHEMICAL PROPERTIES OF THE PEAT AT THE MPOB RESEARCH STATION AT SESSANG, SARAWAK

Property	Shallow peat	Deep peat
pH (H ₂ O)	3.54	3.35
Organic carbon (%)	24.50	24.86
Nitrogen (%)	1.21	2.98
C/N ratio	20.3	8.3
Extractable phosphorus (mg kg ⁻¹)	73.8	42.9
Exchangeable cations (cmol kg ⁻¹)		
Potassium	1.23	0.86
Calcium	7.00	4.05
Magnesium	4.45	3.65
Total exchangeable bases	12.68	8.57
Aluminum (mg kg ⁻¹)	1.35	0.53
Manganese (mg kg ⁻¹)	24.5	21.4
Iron (mg kg ⁻¹)	108.8	75.2

Note: Peat samples collected at 0-45 cm depth.

Peat Depth and Soil Bulk Density

Peat depth and soil bulk density are the most important properties that influence management practices of oil palm on peat. The thickness of the peat layer has been used in the classification of peat soils as well as for its agronomic suitability for oil palm planting. The loose and soft ground conditions associated with low soil bulk density present anchorage problems for the palms, poor growth and yield, and also a constraint to accessibility. Low soil bulk density is among the peat properties that need amelioration for successful cultivation of tree crops such as oil palm. Mohd Tayeb *et al.* (1996) reported that good soil compaction increased soil bulk density up to 0.23 g cm⁻³, giving positive effects to palm growth, yield production and field accessibility.

The effects of peatland development and reclamation for oil palm planting on the peat properties over a 10-year period at the MPOB Research Station Sessang are summarized in Table 4. Lowering the water-table by draining the area resulted in peat subsidence which led to decrease peat depth besides increasing soil bulk density. Over the period of 10 years, the initial peat depths were reduced from 135.0 to 63.3 cm and from 362.1 to 277.7 cm for the shallow and deep peats,

respectively. For the deep peat, the total subsidence over the 10-year period was slightly higher than 84.4 cm (23.3%) compared to 71.1 cm (52.7%) for the shallow peat. The initial soil bulk density of drained peat was low, averaging 0.14 and 0.09 g cm⁻³ for the shallow and deep peats, respectively, which posed problems to oil palm development and management. Mechanical soil compaction and natural peat subsidence over the 10 years of development increased soil bulk density up to 0.26 and 0.16 g cm⁻³ for the shallow and deep peats, respectively.

Peat Subsidence

An unavoidable effect of draining peatland for oil palm cultivation is the irreversible ground surface subsidence. Subsidence of drained peat can be divided into three components, namely consolidation, oxidation and shrinkage. The type of peat, degree of decomposition, depth of water-table and ground vegetation are among the factors that influence the rate of subsidence. In Sarawak, a subsidence of 60 cm during the first two years after peat reclamation, followed by a rate of 6 cm yr⁻¹ thereafter with the water-table maintained at 75-105 cm below the surface, was reported (Tie and Kueh, 1979). Gurmit *et al.* (1986) reported that, under oil palm cultivation, a subsidence of 5-7 cm yr⁻¹ in

TABLE 4. EFFECTS OF LAND DEVELOPMENT FOR OIL PALM PLANTING ON PEAT PROPERTIES (at 0-30 cm depth) AT THE MPOB RESEARCH STATION AT SESSANG, SARAWAK

Peat category	Peat depth (cm)		Soil bulk density (g cm ⁻³)	
	Initial ¹	Current ²	Initial ¹	Current ²
Shallow peat	135.0 ± 1.3	63.3 ± 1.3	0.14 ± 0.03	0.26 ± 0.04
Deep peat	362.1 ± 2.5	277.7 ± 2.1	0.09 ± 0.01	0.16 ± 0.03

Note: ¹Drained peat. ²Ten years after development.

the early years of peat development was recorded before the rate settled down to 2-4 cm yr⁻¹ in the subsequent years.

The progress of subsidence for peat under oil palm cultivation at the MPOB Research Station, Sessang is presented in *Figure 3*. Generally, the subsidence rate decreased with each year following land development, resulting in a total subsidence of 96.5 cm over 17 years, or an average of 5.7 cm yr⁻¹. A subsidence rate of 29 cm yr⁻¹ was recorded during the first year of development, and was mainly due to mechanical soil compaction using an excavator during the land preparation phase. During second year after development, the subsidence rate decreased to 17 cm yr⁻¹, followed by 5-6 cm yr⁻¹ over the next period of three to nine years after development. Thereafter, the subsidence rate was recorded at 2-4 cm yr⁻¹. The subsidence rate at the study area was relatively lower compared to

previous reports, and was mainly due to the higher water-table condition.

Field Water-table

In the natural state, peatland is generally saturated with water. For successful oil palm planting, the field water-table should be maintained at 50-70 cm below ground surface for optimal palm growth and yield, as well as to improve the soil bearing capacity and to minimize peat subsidence (Mohd Tayeb, 2005). A water-table study conducted at United Plantations Bhd indicated that extremely high and low field water-table levels seriously affected FFB yields, leading to nearly 15% losses compared to the optimum water-table level (Gurmit, 2004).

Generally, the study area experienced high water-table conditions, averaging from 30-65 cm below the ground level (*Figure 4*). Due to the pre-

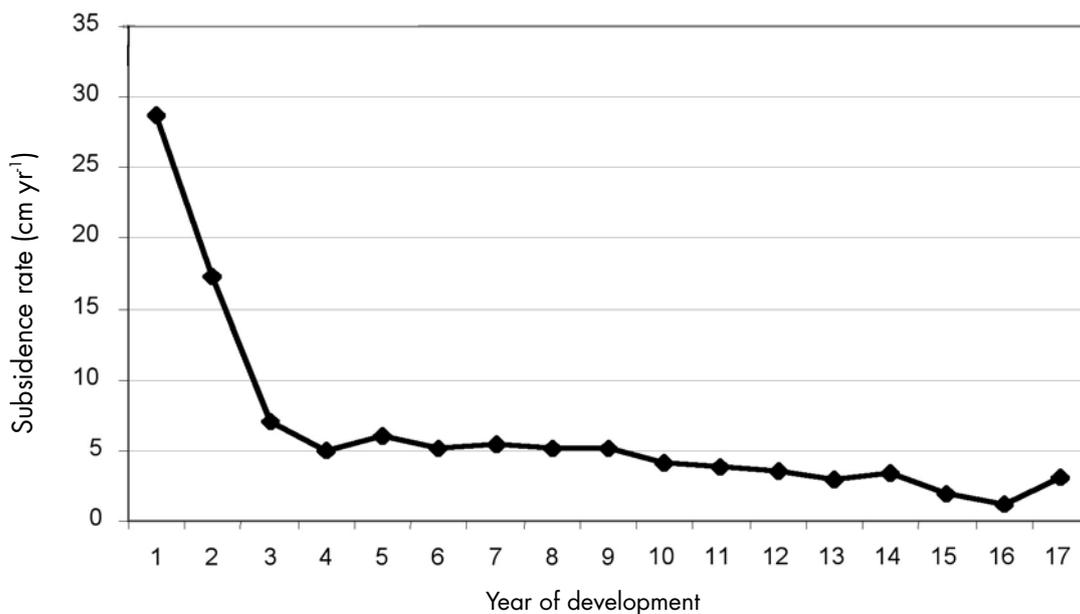


Figure 3. Progress of subsidence of the drained peat under oil palm cultivation at the MPOB Research Station, Sessang, Sarawak.

vailing high rainfall, the water-table could not be maintained at the optimal level even though the study area had an efficient and sufficient drainage network system and good water management. *Figure 5* shows the annual pattern of water-table levels in the study area. The water-table levels were high in early years of planting, ranging from 30-40 cm below the ground level, and thereafter was maintained at an average of 40 cm depth. The annual pattern of water-table levels also indicate these water-table levels were not reflected in the lowering of the ground surface level due to subsidence. These results indicate that in a high rainfall environment, a high field water-table level is unavoidable, and

has become a serious limitation to oil palm growth and yield. *Figure 6* indicates that an increase in field drain intensity up to one per every four plant rows did not influence water-table levels much.

Incidence of Leaning Palms

Leaning of palms has apparently become a serious limitation factor in oil palm performance on peat, especially for the deep peat. Hasnol *et al.* (2007) reported that the effect of leaning incidence on FFB yield production varied, ranging from 9% to 26% lower yields compared to the upright palms. It was noted that the degree of palm leaning under

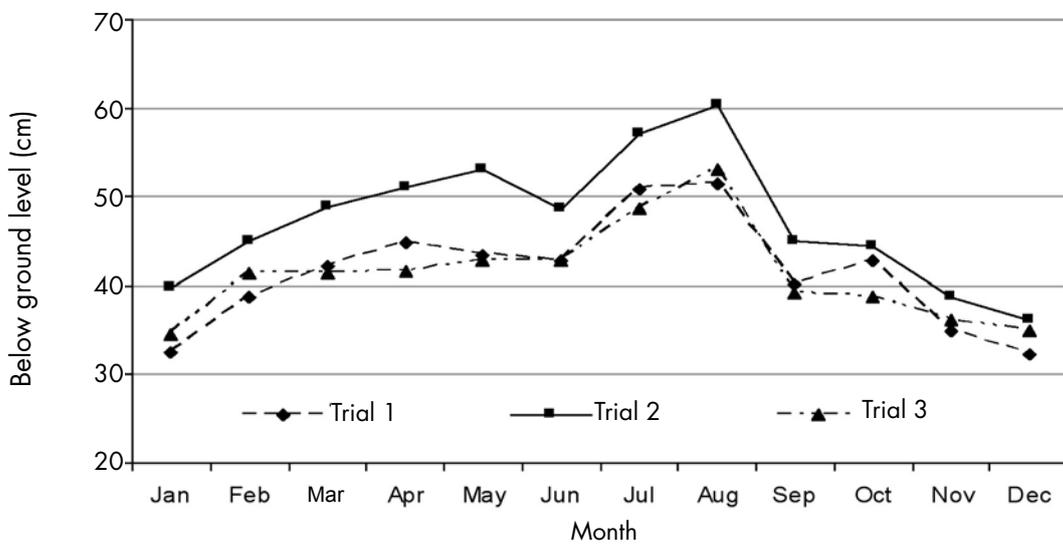


Figure 4. Summary of the mean monthly field water-table levels (means over 1993-2007) at the MPOB Research, Sessang, Sarawak.

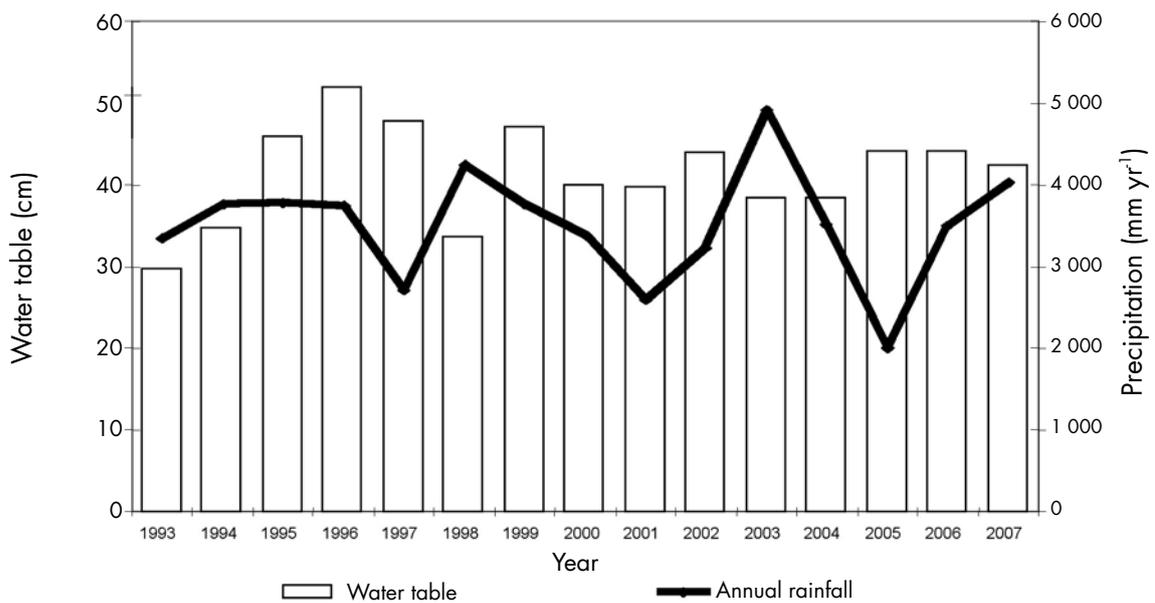


Figure 5. Summary of the mean yearly field water-tables at the MPOB Research Station, Sessang, Sarawak.

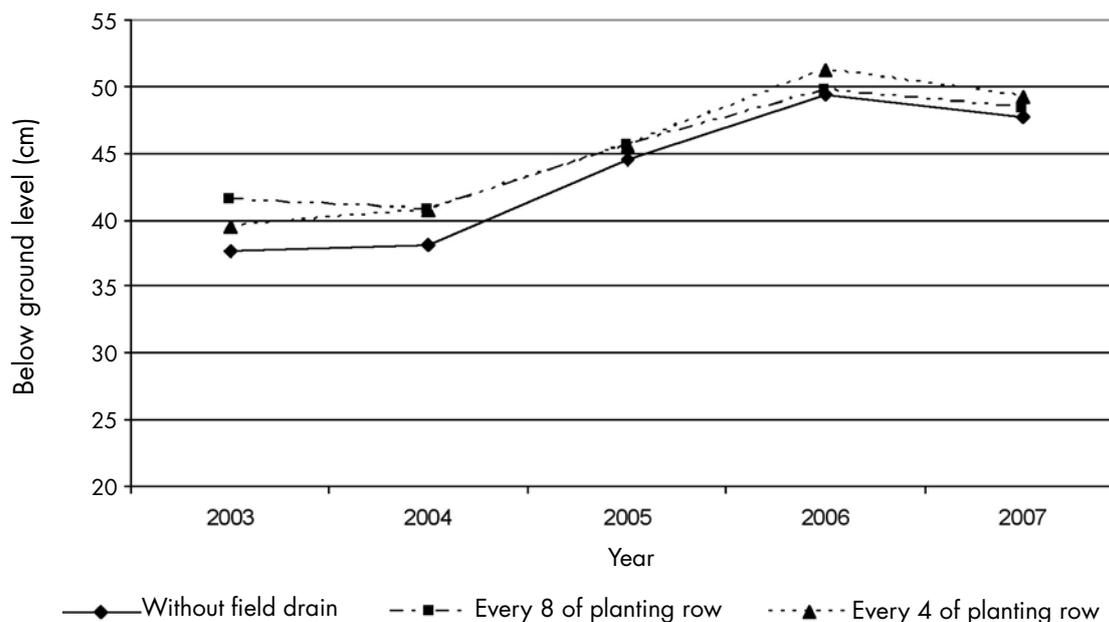


Figure 6. Effect of field drain intensity on water-table.

the mild and progressive categories changed slightly the canopy arrangement subsequently, but did not seriously affect FFB yield as well as field management. On the other hand, severe palm leaning which seriously affected FFB yield also posed difficulties in field management due to the haphazard direction of the leaning palms. Experience at the MPOB Research Station, Teluk Intan, Perak, (also on peat) indicated that the incidence of leaning palms is a phenomenon that is unavoidable even in areas which practised mechanical compaction of the peat and the 'hole-in-hole' planting technique.

The incidence of leaning palms at the MPOB Research Station, Sessang over the 12 years after planting is summarized in Table 5. On the shallow peat, almost 100% of the planted palms leaned, of which 54% were in the mild leaning category, 45% recovered, and less than 1% were in the severe or worst

category. Due to the more vigorous palm growth on the shallow peat over the same period, the total incidence of leaning in the shallow peat area was recorded to be higher compared to the deep peat. Data on leaning progress showed that most of the leaning incidence occurred during the early palm age from four to six years after planting, and thereafter occurred more progressively. Field observations suggested that the incidence of leaning palms on the shallow peat had less effect on palm growth and yield production as well as field management. These results indicate that although the incidence of leaning palms on the shallow peat is unavoidable, it could be minimized to a manageable level through the practices of mechanical soil compaction and 'hole-in-hole' planting technique.

On deep peat, 73% of the planted palms leaned, of which 52% were in the mild category and 21%

TABLE 5. OBSERVATIONS ON THE INCIDENCE OF LEANING PALMS (in 12-year-old palms) IN OIL PALM PLANTED ON PEAT AT THE MPOB RESEARCH STATION, SESSANG, SARAWAK

Leaning category	% Incidence of palm leaning		
	Shallow peat	Deep peat ¹	Deep peat ²
Upright palms	0.9 ± 0.2	20.1 ± 15.6	28.3 ± 14.3
Mild and progressively leaning	54.0 ± 23.3	50.3 ± 11.5	55.1 ± 13.8
Severe leaning or toppling	0.6 ± 0.1	2.8 ± 0.8	6.9 ± 1.6
Recovered palms	44.6 ± 22.1	26.8 ± 4.9	9.8 ± 1.0

Note: ¹ Compacted . ² Non-compacted.

were in the severe category. The incidence of leaning palms in the non-compacted area was slightly lower compared with the compacted area due to poorer growth or less vigorous palms in the non-compacted area. In future, a higher incidence of severe leaning or toppling palms is expected due to the high numbers of upright palms, and subsequently this can become a serious yield limiting factor in the deep peat area. Hasnol *et al.* (2007) reported that the incidence of severe leaning for the older palms had a devastating effect on FFB yield, resulting in up to 26% losses caused by a longer period of palm recovery.

Termite Infestation

Lim and Bit (2001) reported that new infestations of termites on deep peat in Sarawak can be as high as 0.4% to 0.8% per month, and treatment of infested palms will reduce the number of dead palms but cannot prevent new infestations. High termite infestation suggests that termites can be a major pest of oil palm on peat even with complete burning during land preparation. Higher frequency of treatment is necessary at the early stages of planting, especially over the period from the second to the fourth year of planting. Lim and Bit (2001) recommended that for effective control of termites on young palms, an early warning system by monthly census and immediate treatment are needed.

Total termite infestation on shallow peat over 10 years after planting was 11.8% of palms, with 9.4% casualties. The trend of termite infestation showed that total infestation declined with palm age. High infestation occurred during the period from the second to the fourth year of planting and ranged from 2.2% to 3.2% per year (*Figure 7*). On deep peat, total termite infestation over nine years after planting ranged from 4.3% to 14.3% (*Figure 8*). Total termite infestation was higher in the non-compacted area and was due to poor in-field accessibility for effective control measures. Field observations showed that the distribution pattern of termite infestation was clustered, and that the adjoining uninfested palms would eventually be infested. Most of the infestation cases showed that the termites entered the palm from the top through the palm spear, and the rotten (infested) tissue moved downward leading to palm death.

FFB Yield Performance

Earlier attempts to plant oil palm on peat had been less successful with palms showing mediocre growth and yield performances. Much of this was due to the lack of understanding on how best to develop and manage this problematic soil. The

adoption of the research findings obtained through time has resulted in the better performance of oil palm. Recently, oil palm yields on peat have equalled if not surpassed those from some of the mineral soils. MPOB's experience over the years from its peat research station at Teluk Intan, Perak, has resulted in achieving and sustaining FFB yields in region between the upper 30 and lower 20 t ha⁻¹ yr⁻¹ at the planting density of 160 palms ha⁻¹ (Mohd Tayeb, 2005).

Early FFB yields of oil palm planted on peat at the MPOB Research Station, Sessang are summarized in *Figure 9*. On deep peat, the mean cumulative FFB yields over eight years were 20.18 and 18.06 t ha⁻¹ for the compacted and non-compacted areas, respectively; in other words, yields were 10% higher for the compacted area. FFB yields over eight years showed an increasing trend with palm age for both compacted and non-compacted areas. In the compacted area, the first year FFB yield was 7.53 t ha⁻¹; it then increased to 9.34 and 20.79 t ha⁻¹ in the second and third years, respectively. Over the subsequent period from the fourth to the eighth years, FFB yields on compacted deep peat were recorded at more than 23 t ha⁻¹, with a maximum of 26.07 t ha⁻¹. FFB yield in the non-compacted area showed an improving trend with year of harvesting. Over the seven-year period, FFB yields were lower in the non-compacted area compared to the compacted area, ranging from 8%-18% lower than the yields from the compacted area, but were equal by the eighth year.

Over the same period of harvesting, the cumulative FFB yield from the shallow peat was 19% and 33% higher compared to the compacted and non-compacted deep peat areas, respectively. High FFB yields were obtained in the early years of production, ranging from 15 t ha⁻¹ in the first year, then increasing to nearly 30 t ha⁻¹ by the fourth year. However, FFB yields decreased markedly after the palms became fully mature at eight years after planting, thereafter ranging from 21 to 28 t ha⁻¹. High incidences of leaning palms and inter-palm competition (due to high planting density) during the fully mature palm phase directly influenced FFB yield potential over that period.

CONCLUSION AND RECOMMENDATION

Peat is a marginal soil that in its original state has many physical and chemical constraints to oil palm planting. Low macronutrient contents, low pH and high C:N ratio are among the inherent chemical properties for both shallow and deep peats at the MPOB peat research station in Sessang, Sarawak. Soil analyses also indicated that there was adequate Ca and Mg in the peat to meet the

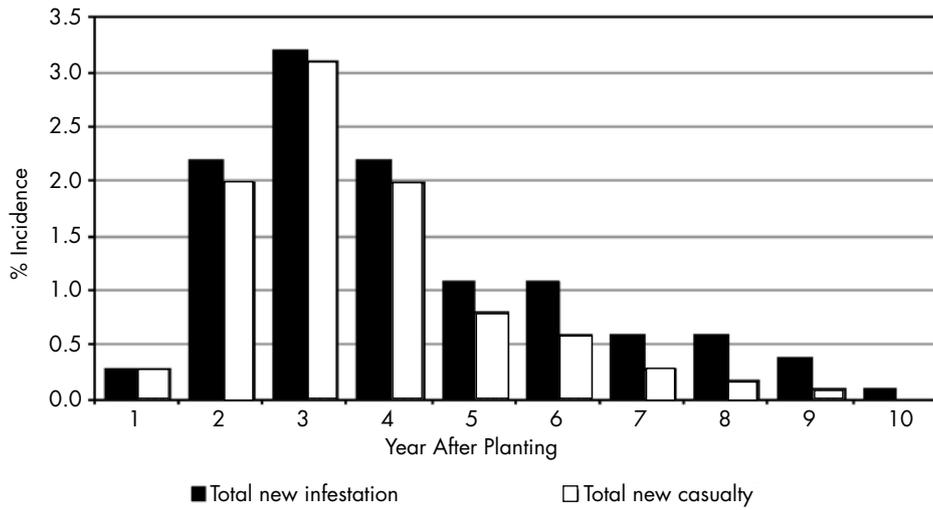


Figure 7. Distribution of termite infested palms on shallow peat at MPOB Research Station, Sessang, Sarawak.

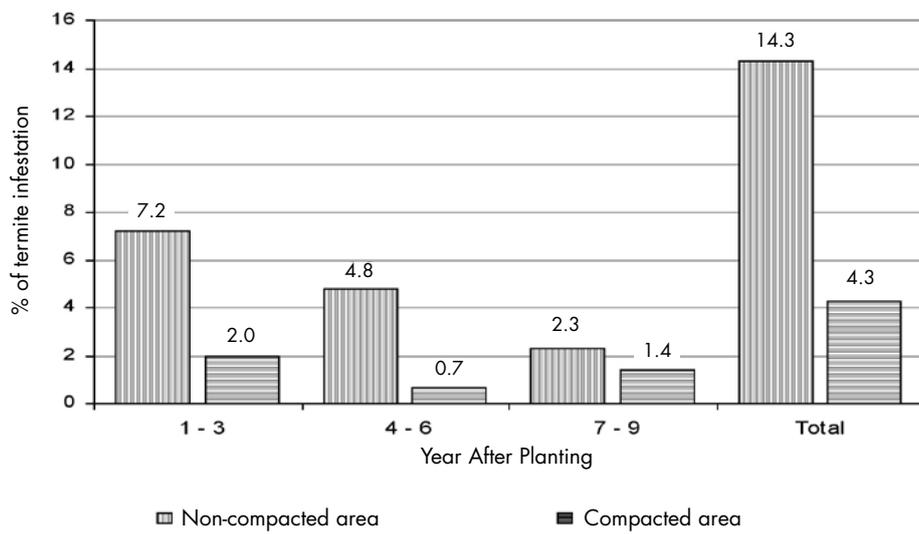


Figure 8. Distribution of termite infested palms on deep peat at MPOB Research Station, Sessang, Sarawak.

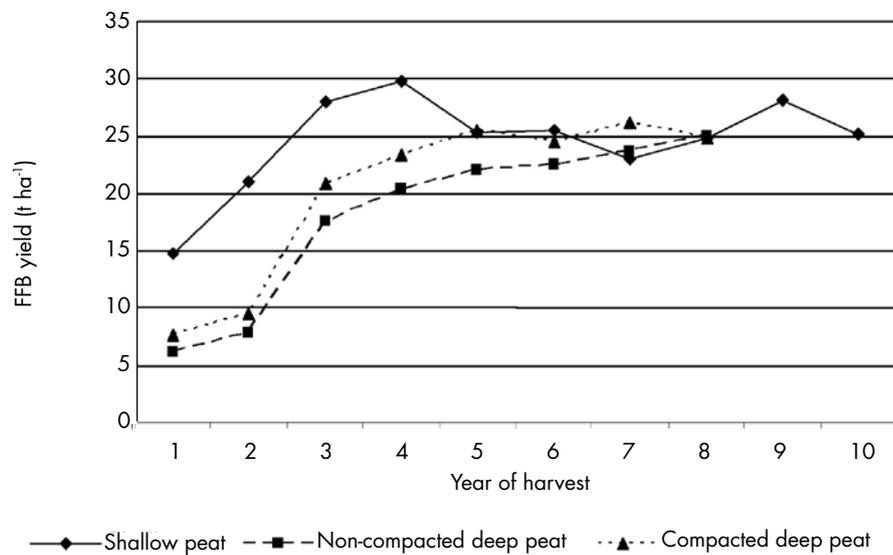


Figure 9. Early fresh fruit bunch (FFB) yields of oil palm planted on peat at MPOB Research Station, Sessang, Sarawak.

palm's requirements, at least in the early years of planting. These properties seriously affect palm growth and yield which need appropriate fertilizer management. Fertilizer application in peat areas in Sarawak becomes more critical due to the high leaching environmental conditions such as high rainfall and high water-table.

Under its natural state, peat is often waterlogged with its woody components remaining intact under sustained anaerobic condition. Once the peat is drained, oxidation sets in resulting in the decomposition and mineralization of the organic matter, subsequently changing the whole physical profile of the peat. Over 10 years of development, the natural processes as well as soil compaction during land preparation improved soil bulk density to 0.26 and 0.16 g cm⁻³ for shallow and deep peat, respectively, while peat depth was reduced by 70 to 85 cm. The subsidence rate decreased over time with total subsidence after a 17-year period of 96.5 cm and more than 50% of the subsidence occurring during the first three years.

On peat, with the provision of good land preparation, water management, optimum planting density and sufficient fertilizer application, FFB yields of 30 t ha⁻¹ yr⁻¹ are attainable. MPOB's experience in planting oil palm on peat under the Sarawak environment indicates that high water-table, leaning palms and termite infestation are major limitations that seriously affect palm growth and yield production. FFB yields at the MPOB Research Station, Sessang were slightly lower relative to expected yield potential. From the data collected, it can be seen that FFB yields on shallow peat are higher than on deep peat, and that soil compaction significantly improved palm growth and yield production as well as reducing termite infestation.

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