BEST MANAGEMENT PRACTICES FOR OIL PALM PLANTING ON PEAT: OPTIMUM GROUNDWATER TABLE

HASNOL OTHMAN; AHMAD TARMIZI MOHAMMED; MOHD HANIFF HARUN; FARAWAHIDA MOHAMAD DARUS and HASIMAH MOS

528

MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2010

MPOB TT No. 472

Drainage and water management is an integral part of peat development for oil palm planting. An efficient and adequate drainage network system as well as for water management is the key to the successful planting of oil palm on peat. The main objectives of water management are:

- to retain an optimum water-table for superior palm growth and high yield production;
- to drain out excess water and avoid prolonged flooding periods;
- to minimize excessive peat subsidence, thus, minimizing CO_2 emission;
- to avoid irreversible drying of the peat surface; and
- to minimise the risk of peat fires.

Generally, the drainage system for water management consists of an inter-connected network of field, collection and main drains as well as canals of varying dimensions and intensities depending upon the hydrological and rainfall characteristics of the area. The drainage system design should be based on such hydrological characteristics of peat as hydraulic conductivity, groundwater level, water-holding capacity, available water and permeability. The rate of water movement through the peat is highly relevant to drainage problems, and it is influenced by the type of peat, its degree of decomposition and bulk density. The subsidence rate and CO_2 emission are very much related to the depth of groundwater table. A carbon emission of 86 t CO_2 ha^{-1} from oil palm planting on peat has been estimated by Hooijer *et al.* (2009) using the following equation:

$$CO_2 \text{ emission } (t\ ha^{-1}\ yr^{-1}) = 0.91 \times \text{water-table depth (m)}$$

Based on the performance of oil palm planted on peat in Peninsular Malaysia, it is suggested that the groundwater table be maintained at a depth of 50 to 70 cm below the peat surface (Gurmit *et al.*, 1987; Mohd Tayeb, 2005). Ahmad Tarmizi *et al.* (2009) reported that the long-term records of groundwater table averaging between 35 and 45 cm in Sessang, Sarawak, have been shown to be able to support good growth of oil palm with high yield production. At the same time, a groundwater table of 35 to 45 cm would be able to limit peat drying and significantly reduce CO_2 emission. Further refinement for better water management is proposed to establish the optimum groundwater table at different phases of oil palm growing and at different peat developmental stages for oil palm cultivation on deep peat in Sarawak.

STUDY AREA

The study was carried out at MPOB's peat research station located at Sessang, Sarawak, which has an area of peatland totalling 1000 ha. The area was previously a secondary mixed peat swamp forest. Initially, the peat depths ranged from 100 to 400 cm, consisting of undecomposed plant biomass (fibric soil materials) and mineral subsoil below the peat layer of non-sulphidic clay. An intensive study on peat subsidence was carried out in 2001, and water management for the whole plantation was improved to maintain the groundwater table in the field. The study tested three planting blocks (20 ha each) with three dif-

ISSN 1511-7871

9 771511 787001

ferent groundwater tables (*Figure 1*). Data on soil water characteristics of the peat, such as groundwater table, water-holding capacity and soil moisture regime, were collected to fill the gaps in knowledge and to improve on the recommendations for sustainable peat development for oil palm. The available water (the difference between the quantity of water retained at field capacity and at permanent wilting point) was measured quantitatively by using the standard pressure membrane method (Anon., 2005).

RESULTS AND DISCUSSION

Soil Water Characteristics

Information on the hydrology and moisture characteristics of peat is important for the design of an efficient drainage system. *Figure 2* shows that the available water of hemic and sapric peat materials was very low, *i.e.* less than 15% of the volumetric moisture content (MC). Values of available water of both hemic and sapric peat materials decreased to below

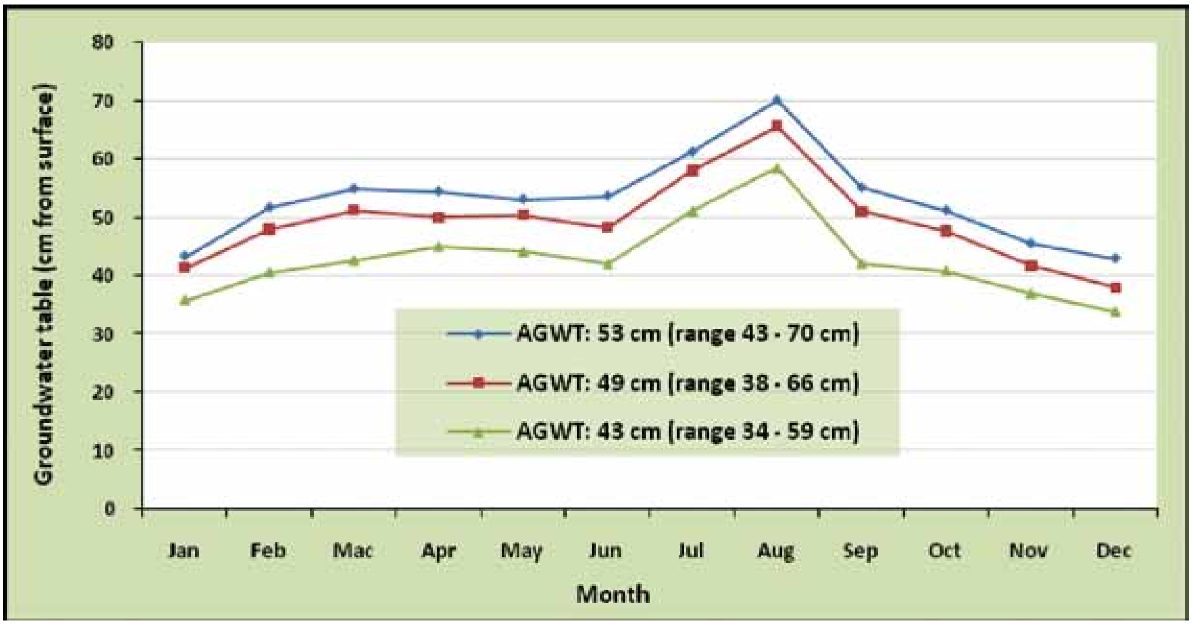

Figure 1. Monthly mean groundwater table in three different blocks planted with oil palm (AGWT: average groundwater table).

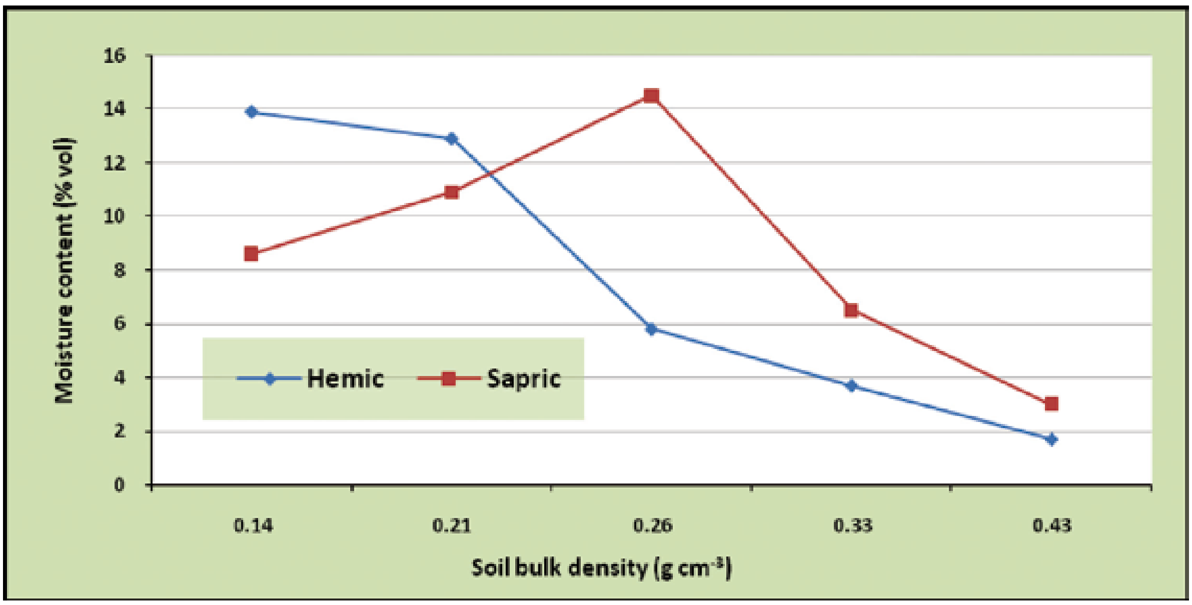

Figure 2. Effect of peat bulk density on available water for hemic and sapric peat materials.

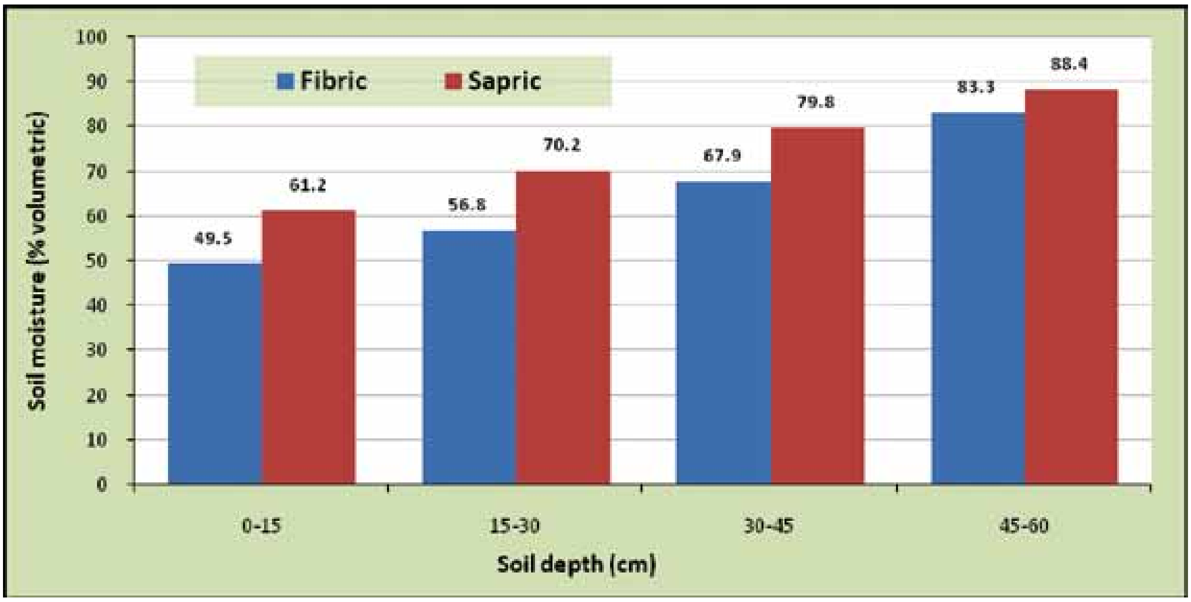

Figure 3. Effect of peat decomposition on soil moisture regime (water level in collection drain at 50 cm) at different soil depths.

10% of volumetric MC as the bulk density increased to greater than 0.26 and 0.33 g cm^{-3}, respectively. *Figure 3* shows that the soil moisture content of the fibric peat materials was lower as compared to the sapric peat materials. Ayob and Melling (2007) reported that peat moisture at permanent wilting point was still relatively high at 50%-60% of volumetric MC, with the peat visually wet but the water may not be available for plant use.

This result clearly indicates that for peat, the water supply from groundwater through capillary rise is very critical, and, thus, a high groundwater table is required. The groundwater level in the planting block is dependent on the intensity of the field drains and the degree of peat decomposition (*Figures 4* and *5*). In order to maintain a uniform groundwater table in the planting block, a higher intensity of field drains (one for every four planting rows) was required for the area with sapric peat materi-

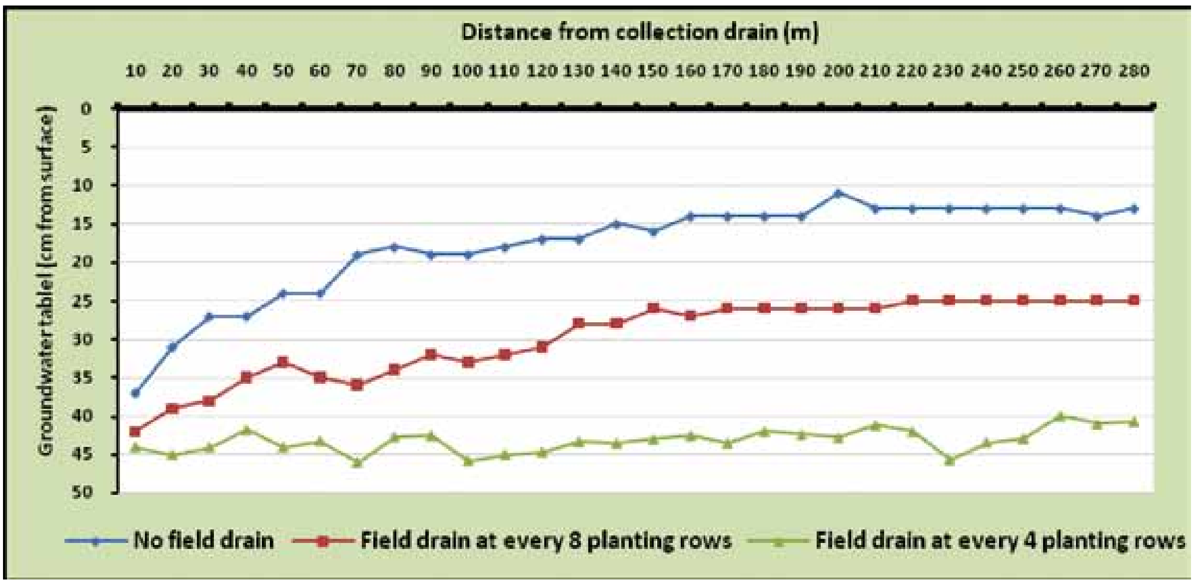

Figure 4. Effect of field drain intensity on groundwater table (water level in collection drain at 50 cm).

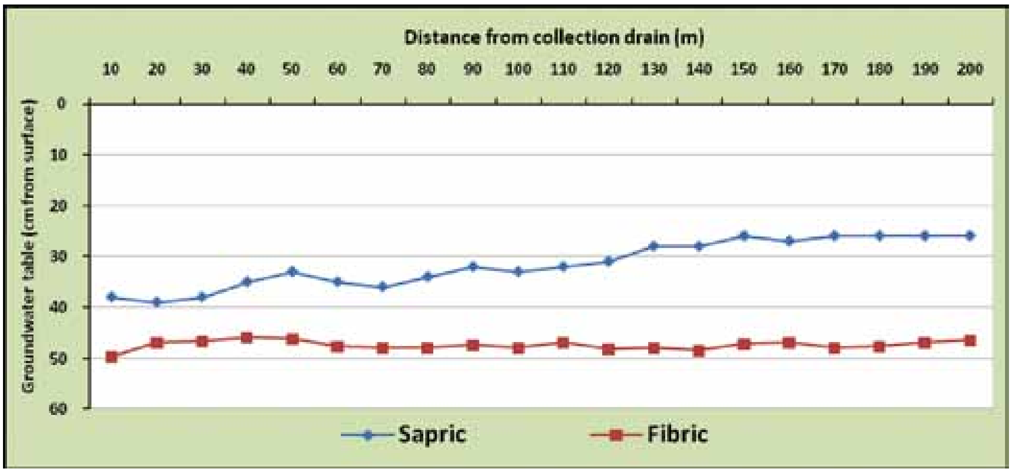

Figure 5. Effect of peat decomposition on groundwater table at various distances from collection drain (water level in collection drain at 50 cm).

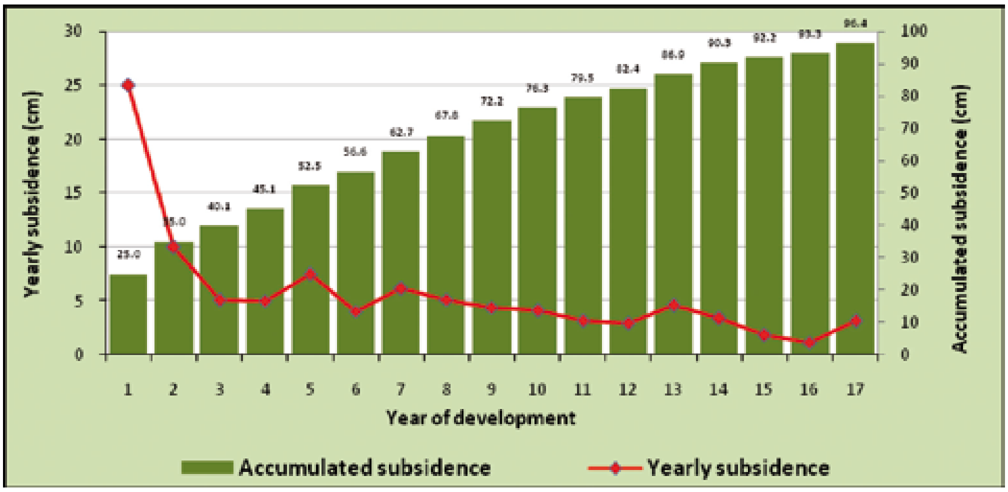

Figure 6. Yearly average and accumulated peat subsidence in the study area.

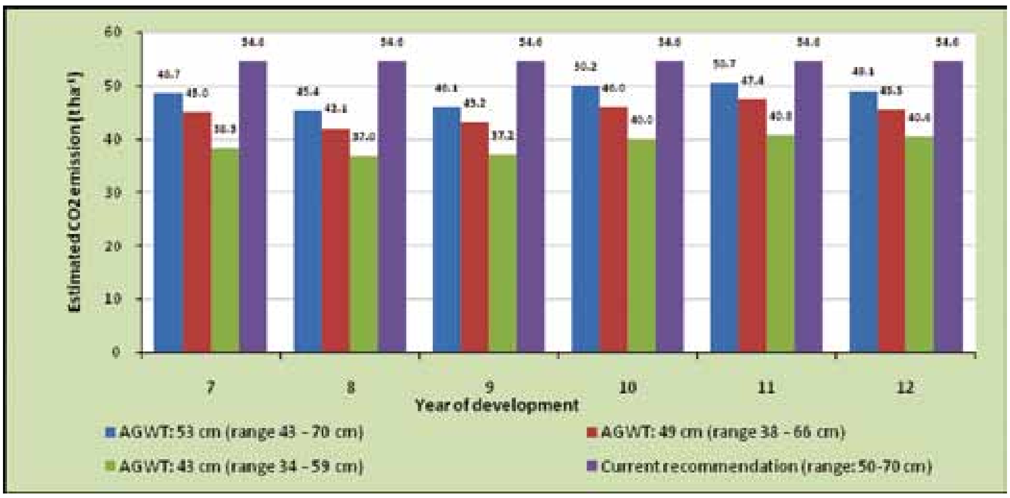

Figure 7. Estimated CO_2 emission at different groundwater tables after 7 to 12 years of peat development.

als, while a lower intensity of field drains was needed for the area with fibric peat materials.

Subsidence and Estimated CO_2 Emission

The progress of peat subsidence under oil palm cultivation in the study area is shown in *Figure 6*. A subsidence rate of 13.4 cm yr^{-1} was recorded during the initial three years of development, followed by 5-6 cm yr^{-1} over the subsequent period from three to nine years after development. Thereafter, the subsidence rate was recorded at 2-4 cm yr^{-1}. The three stages of peat subsidence show that a higher groundwater level could reduce the subsidence rate to below 2 cm yr^{-1} after 15 years of peat development. Overall, the subsidence rate can be significantly reduced by increasing the groundwater table up to 30-40 cm from the surface during the early years of development. This study shows that maintaining the average groundwater table at 43 cm (range: 34-59 cm) reduced the estimated CO_2 emission significantly to levels below 40 t CO_2 ha^{-1} (*Figure 7*). This is significantly lower than the carbon emission of 86 t ha^{-1} yr^{-1} estimated by Hooijer *et al.* (2009) because of the higher subsidence rate due to a water table of 90 cm which was used in the estimation by Hooijer *et al*.

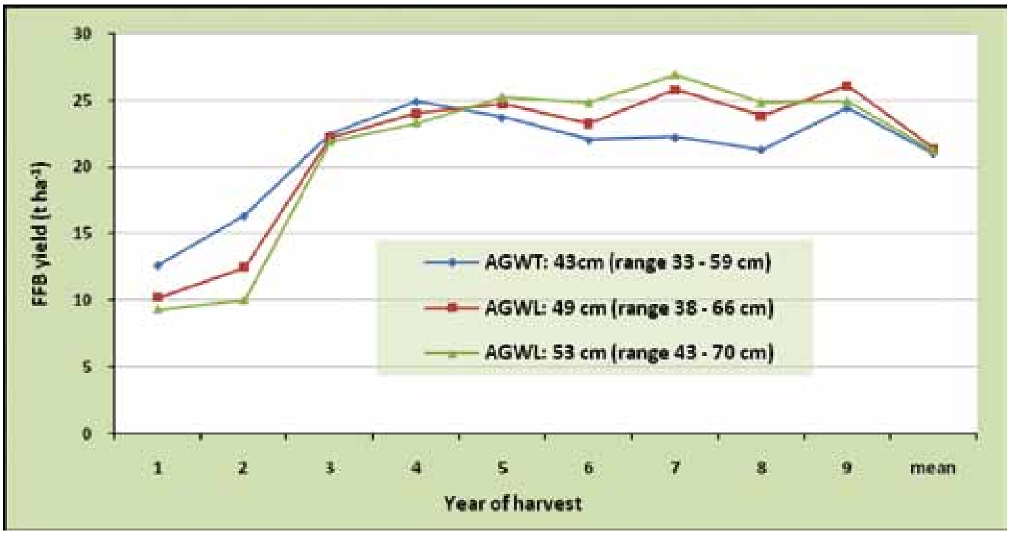

Figure 8. Fresh fruit bunches (FFB) yield profile of three blocks with different groundwater tables.

TABLE 1. WATER MANAGEMENT FOR OIL PALM PLANTING ON PEAT IN SARAWAK

Development stage		Drainage intensity	Water level from ground surface	
Oil palm	**Peat**	**Drain for every oil palm row**	**Groundwater table in field (cm)**	**Water level at collection drain (cm)**
Immature (1 to 3 years old)	Fibric	>8	30 to 40	35 to 45
Young mature (4 to 7 years old)	Hemic	8	35 to 45	45 to 55
Fully mature (> 8 years old)	Sapric	4	40 to 50	50 to 60

Fresh Fruit Bunch Yield Performance

Figure 8 shows that a high oil palm yield could be obtained by maintaining a higher groundwater table. A slightly lower fresh fruit bunch (FFB) yield was obtained during the early years of production, with an average of 10 t ha^{-1} during the first year, increasing up to an average of 25 t ha^{-1} after the fourth year of harvesting. The highest yield was recorded at the 43 cm groundwater table block during the first four years of harvesting but for older palm higher yields were recorded at the 49 cm and 53 cm groundwater table blocks, *i.e*. when peat were already developed from fibric to sapric.

CONCLUSION AND RECOMMENDATIONS

For good oil palm development on peat, water management is crucial in order to minimize peat oxidation and subsidence. The recommendations for optimum groundwater tables vary according to the oil palm developmental stage which is also correlated to the peat development stage, as shown in *Table 1*.

The height of groundwater table fluctuates within a certain range depending on rainfall; the smaller the range of fluctuations, the lower the rate of peat subsidence. In order to maintain a recommended groundwater table in a planting block, the water level in the collection drain has to be consistently lower than the recommended groundwater table by 5-10 cm. This is done by using weirs made of sand bags and wooden planks set up along the collection drain. Water from the collection drain then flows to the main drain, where the water flowing into the river is regulated by water gates of concrete structure.

For best management practices in water management, the following are proposed:

1. The field design needs to provide space to accommodate the manoeuvring of machinery used for the maintenance of the collection and main drains;

2. The intensity of field drains needs to vary according to the peat decomposition stage, *i.e*. a higher intensity is required for an area with sapric peat materials as compared to an area with fibric peat materials;

3. The peat surface topography must be considered, where it rises to form a dome;

4. The groundwater table must be monitored regularly by checking the water levels in the collection drain and checking the piezometers installed in the planting block; and

5. The drainage system should be able to maintain the water quality by flushing out the stagnant water in the field drains during the wet season.

REFERENCES

AHMAD TARMIZI MOHAMMED; HASNOL OTHMAN; FARAWAHIDA MOHD DARUS; MOHD HANIFF HARUN; MUHAMMAD PILUS ZAMBRI; ISMAIL A BAKAR and HENK WÖSTEN (2009). BMP on peat in relation to carbon emission. *Proc. of the PIPOC 2009 International Palm Oil Congress – Balancing Ecologies with Economics*. 9-12 November 2009. Kuala Lumpur Convention Centre. p. 18.

ANON. (2005). Operating Instructions: 08.03 Pressure Membrance Apparatus. www.eijkelkan.com

AYOB, K and MELLING, K (2007). Moisture retention curve of tropical sapric and hemic peat. *Malaysian Journal of Civil Engineering, 19(1)*: 84-90.

GURMIT, S; TAN, Y P; RAJAH PADMAN, C V and LEE, F W (1987). Experiences on the cultivation and management of oil palms on deep peat in United Plantations Berhad. *The Planter, 63*: 143-157.

HOOIJER, A; PAGE, S; CANADELL, J G; SILVIUS, M; KWADIJK1, J; WÖSTEN, H and JAUHIAINEN, J (2009). Current and future CO_2 emissions from drained peatlands in Southeast Asia. *Biogeosciences Discuss*., *6*: 7207-7230.

MOHD TAYEB, D (2005). *Technologies for Planting Oil Palm on Peat*. MPOB, Bangi. 83 pp.

For more information, kindly contact:

Director-General
MPOB
P. O. Box 10620
50720 Kuala Lumpur, Malaysia.
Tel: 03-8769 4400
Fax: 03-8925 9446
www.mpob.gov.my