Agronomic Management of Oil Palms on Deep Peat

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The special soil physicochemical characteristics of deep tropical peat soils and their environments are documented in order to explain the need for adequate drainage, compaction and nutrition in oil palm development on these "problem soils." Successful techniques of land preparation, nursery establishment, and planting procedures are presented together with fertilizer recommendations and yield response on peat soils in comparison to mineral soils.

Worldwide, there are approximately 25 million ha of peat land in oil palm growing countries (**Table 1**). Some of this land is considered suitable for oil palm development due to its rather homogeneous soil features, its constant availability of water, and its flatness – all in support of uniform yield characteristics in oil palm.

Table 1. Global distribution of peat lands in oil palm growing regions (after Andriesse, 1988; Driessen, 1978).

Region	Million ha
Malaysia	2.4
Indonesia	16.0
Others	0.6
Asia	**19.0**
Zaire	1.0
Guinea	0.5
Others	0.6
Africa	**2.1**
Brazil	1.0
Others	2.8
Central & South America	**3.8**
Total	**24.9**

The availability of modern 'heavy' equipment and improvements in knowledge and understanding of oil palm nutrition have now made the development of deep peat technically feasible. However, considerable expenditure for road construction, drainage, soil compaction, soil preparation, and mineral fertilizer, as well as practical experience and knowledge of peat and peat management, is required for successful oil palm development on these "problem soils."

More than 76 percent of the world's tropical peat lands are found in Malaysia and Indonesia. About 90 percent of this area is located on the islands of Borneo and Sumatra, but so far only 200,000 to 300,000 ha have been developed for oil palm.

(At left) Palms tend to lean over when planted in unconsolidated peat. To avoid this, the "hole-in-hole" method must be used.

(At right) Well-established oil palm on peat soil due to proper water management and use of proper planting techniques.

What is peat? Peat soils consist of partly decomposed biomass and develop in depressions or wet coastal areas when the rate of biomass production from adapted vegetation (i.e., mangroves, swamp forest) is greater than the rate of decomposition. This is due to the presence of a permanently high water table that prevents aerobic decomposition of plant debris (Andriesse, 1988; Driessen, 1978).

Ombrogenous peat usually develops in shallow depressions where it soon rises like an hourglass above the water table. As the area develops, it becomes increasingly dependent on nutrient deposition from the atmosphere, contained in rain and dust, which results in the formation of very acid peat soils of low fertility status.

Topogenous peat is formed in flood plains and is usually enriched by the influx of nutrients from through-flow and the deposition and sedimentation of minerals during temporary flooding and, therefore, is less acid and more fertile.

Thus, the properties of peat soils...mostly classified as Tropofibrists and Tropohemists in the USDA soil order of Histosols...in contrast with mineral soils, are characterized by:

- Very low bulk density (100 to 200 kg/m^3 compared with 1,400 to 1,800 kg/m^3 for most mineral soils)
- Low nutrient content, except for nitrogen (N)
- Poor nutrient retention capacity, especially for potassium (K)
- Rapid fixation of water soluble copper (Cu) and zinc (Zn) compounds by humic and fulvic acids and polyphenolic compounds
- Low to very low pH (pH 2.8 to 4.5)
- Very large content (up to 98 percent) of organic matter (OM)...a fire hazard when dry
- Very large water holding capacity

Land Preparation

The spongy character of peat is a major reason for shrinkage following drainage at the beginning of peat soil preparation for oil palm planting.

The development of a functional water management system – involving drainage but also maintenance of a water table close to the surface to prevent excessive drying – is a prerequisite step for successful oil palm establishment on peat.

Table 2. Dimensions for drains in oil palm established on deep peat (Gurmit Singh, 1983).

Drain type	Width, m: Top	Width, m: Bottom	Depth, m
In-field	1.0 - 1.2	0.5 - 0.6	0.9 - 1.0
Collection	1.8 - 2.5	0.6 - 0.9	1.2 - 1.8
Main	3.0 - 6.0	1.2 - 1.8	1.8 - 2.5

The system should be meticulously planned following a thorough field survey during the dry season and inspections during periods of flood.

During monsoon rains, the system must be able to accommodate a greater volume of flow, as oil palm roots will be affected by reduced aeration in stagnant water.

During periods of drought, water must be conserved to prevent irreversible drying of peat and drought stress on newly planted oil palms. Thus, a gate with removable wooden blocks is required at each palm block to maintain the water level between 50 to 80 cm from the peat surface.

Wherever possible, main drains are installed along existing (natural) drainage lines. Collection drains are installed on the lower side of each 200 m wide block so that in-field drains run down the slope towards collection drains and bridges are not required to connect the harvest road with harvest paths. In-field drains are installed at eight row intervals, or 59 m apart, where plant density is 160 palms/ha. Poorly drained patches may require additional in-field drains (dimensions are given in **Table 2**). Initial deep drainage is required to induce physical shrinkage and 'self compaction' of the peat material which may be as much as 1 m in the first year.

The aim is to compact the soil mechanically after the peat has shrunk following drainage and thereafter control the rate of subsidence by manipulating the water table.

Properly compacted peat has excellent capillarity and water holding capacity, will improve anchorage for the oil palm (less leaning and "falling over" of palms at maturity), increases the supply of nutrients, reduces the risk of fire, termite and white ant attacks, and supports more rapid growth and larger yields of fruit bunches.

A field can only be considered ready for planting after all drains have been installed and the planting path and planting circles have been cleared and compacted. "Less costly" alternatives invariably result in failure.

Figure 1. (Clockwise) (1) Excavator with punch attachment, (2) compacting, and (3, 4) preparing a planting hole-in-hole (courtesy of PT Group Plantations, Indonesia).

Much misguided effort is invested in the difficult task of establishing legume cover plants (LCP) on infertile, very acid peat soils where there is no benefit from biological nitrogen fixation (BNF). Peat soils are not prone to erosion, additional organic matter is not required, and the LCP may increase the risk of fire during dry periods.

However, since slash and burn is not permitted, it may be necessary to establish LCP to increase the rate of decomposition of stacked woody vegetation after land clearing and reduce the number of potential breeding sites for rhinoceros beetles (*Oryctes rhinoceros*).

Nursery and Planting

Because of its physicochemical properties, peat soil is quite unsuitable for use in oil palm nurseries, and mineral soils should be used instead.

Since frond length tends to be shorter in palms grown on peat

Table 3. Generic fertilizer recommendations for palms planted on deep ombrogenous peat where bunch ash is not available.

Nutrient:	N	P	K	Cu	Zn	B
Fertilizer (source):	Urea	RP	KCl	$CuSO_4$	$ZnSO_4$	Borate
Rate:	kg fertilizer/palm					
Planting hole	0.25			0.02	0.02	–
Month 3	0.25	–	0.5	–	–	–
Month 6	0.50	0.50	0.5	0.20	0.10	–
Month 9	0.50	0.50	0.5	–	–	0.10
Total Year 1	1.25	1.25	1.5	0.22	0.12	0.10
Year 2	1.50	1.50	3.5	0.20	0.06	0.10
Year 3	1.50	1.50	5.0	0.10	0.05	0.10

(especially ombrogenous peat) than on mineral soils, higher planting densities (commonly 160 palms per ha) are usually required to achieve an optimum leaf area index (LAI).

In order to establish palms properly on deep peat, a "triple hole" procedure is recommended. First, the peat is compacted by 0.5 to1.0 m at each planting point using the tracks and bucket of a swamp excavator (Rasmussen *et al*., 1982). The peat is then compacted at each planting point using a specially constructed attachment (see **Figure 1**).

Palms are then planted into a "hole-in-hole-in-hole". If the land is properly prepared, one machine can prepare up to 1,000 holes per day (about 6 ha).

Proper planting in a recessed and compacted hole is a key step in oil palm development on deep peat, and no compromise should be allowed in this operation.

Fertilization

Adequate fertilization is essential to successful palm oil production on deep peat.

An ameliorative application of finely ground reactive rock phosphate (RRP) together with bunch or wood ash or burnt lime (quick lime) in and around the planting hole results in an increase in the availability of N, phosphorus (P), K, and other plant nutrients by increasing the rate of peat decomposition and mineralization.

Where bunch ash or wood ash is not available, plant nutrients have to be supplied entirely from mineral fertilizers (**Table 3**).

Nitrogen. Peat soils contain large amounts of N. As mentioned earlier, the application of alkaline, high pH material such as bunch ash, wood ash, burnt lime, or rock phosphate (RP) increases the rate of decomposition and the mineralisation of N. Thus, an annual application of 0.6 kg N per palm (e.g., 1.25 kg urea per palm) is usually sufficient during the first year in the field.

Phosphorus. Annual rates of 300 to 400 g P_2O_5 per palm are usually sufficient during the immature growth period. Because of the high acidity in peat soils, fine ground RRP (1.0 to 1.25 kg RRP per palm per year) is the preferred source of P.

Potassium. Potassium is commonly the most deficient nutrient on peat soils. Rates of 2 to 4 kg K_2O per palm applied as KCl or appropriate combinations of KCl and Sul-Po-Mag/K-Mag are required in 3 to 4 split applications to avoid large leaching losses. Where bunch ash is available – which indirectly would contribute to the supply of N, P and micronutrients as described above – 6 kg bunch ash per palm per year is usually sufficient to meet the crop demand during the development phase.

Magnesium. "Indigenous" magnesium (Mg) deficiency in peat soil is not common, but Mg fertilizer may be required to correct Mg deficiency induced by large applications of K (Turner and Bull, 1967).

Calcium. While addition of calcium (Ca) as a nutrient is usually not required, Ca as a component of burnt lime is recommended to increase the rate of peat decomposition. Calcium uptake may thus depress Mg and K uptake.

Copper. Copper is absorbed by the humic and fulvic acids present in organic matter. Therefore, Cu is the most widely deficient micronutrient in deep acid peat soils. Copper deficiency was identified as the cause of "mid-crown chlorosis", which results in reduced vegetative growth and very small fruit bunch yields (Ng and Tan, 1974; Ng *et al.*, 1974; Turner and Bull, 1967). Accordingly, response to Cu (as $CuSO_4$) – both as foliar and basal applications – is large, provided the deficiency is corrected in the first two years after planting.

However, correction of Cu deficiency by these methods requires frequent sprays (1 to 2 per month) or a large basal application.

A promising and innovative technique presently being tested in Borneo provides a low cost but persistent slow release source of Cu. Copper mud balls are prepared by mixing $CuSO_4$ and wet clay soil in a ratio of 1:1 or 1:1.5. Two partially dried mud balls (each 0.75 to 1.0 kg) are inserted into the peat close to the seedling and are expected to supply sufficient Cu for each palm during the first 2 to 3 years after planting (von Uexküll, pers. comm.).

Table 4. Development of annual palm oil yields on a tropical peat soil compared to a typical mineral soil in Malaysia (after Ng et al., 1990).

	CPO, t/ha	
Year after planting	Peat soil*	Class I clay**
3	0.75	–
4	2.34	1.43
5	4.14	3.33
6	5.36	4.54
7	6.56	5.26
8	6.40	5.26
Total	25.55	19.82

*Average of 200 ha. **Malaysian average on class I clay soils.

Boron. The supply of boron (B) in most peat soils is insufficient to meet the requirements of vigorously growing oil palms. In most cases, the use of compound fertilizer containing NPK plus trace elements (micronutrients) or annual applications of 0.1 kg sodium tetraborate per palm will prevent the occurrence of B deficiency.

Table 5. Annual fertilizer nutrient application for immature and mature oil palms established on tropical peat soils in W. Malaysia* (after Ng *et al.*, 1990).

	kg/ha/year						
Phase	N	P_2O_5	K_2O	MgO	CaO	B_2O_3	$CuSO_4$
Immature	50-100	65-80	140-260	–	140-230	6-12	1-2
Mature	120-160	50-70	550-700	0-10	300-400	13-18	3-5

*158 palms per ha planted at the age of 14 to 15 months.

Zinc. To prevent Zn deficiency, often related to a complex nutritional disorder called "peat yellows", a quality compound fertilizer containing Zn and other micronutrients should be used during the immature phase.

Yield Performance. Large yields, comparable to those obtained on mineral soils, are obtained from palms planted on deep peat soils, provided correct water and nutrient management techniques have been used.

Based on larger scale tests that target a maximum exploitation of genetic yield potential, total cumulative yields of 25.6 tonnes crude palm oil (CPO) per ha were produced on a Tropofibrist (pH: 3.9; total N: 1.5 percent; available P: 15 mg/kg; exchangeable K: 0.15 cmol/kg; exchangeable Mg: 2.05 cmol/kg) in Malaysia between year 3 and year 8 following planting. This yield was almost 6 tonnes above the average CPO yield accumulated during the same period on class 1 clay soils (Ng *et al*., 1990) (**Table 4**).

Obviously, such yield developments offer substantial economic incentives to oil palm growers on peat soils and more than compensate for the large investments required for efficient water management and road systems.

However, such impressive yields require adequate nutrient inputs during immature and mature phases of oil palm development (**Table 5**). BCI

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