PART 1

Oil Palm Cultivation

Climate and Soil

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Nursery

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Immature plantings

Mature plantings

Scientific name	*Elaeis guineensis* Jacq.	*Elaeis oleifera* (Kunth) Cortés
Common name	African Oil Palm	American Oil Palm
Malay name	Kelapa Sawit, Kelapa Bali	Kelapa Sawit
Chinese name	油棕榈，油棕	油棕榈，油棕
Group	Monocot	Monocot
Family	Arecaceae	Arecaceae
Duration	Perennial	Perennial
Growth habit	Tree	Tree
Origin	West Africa	South and Central Americas

Oil palm is found growing in wild, semi-wild and cultivated states in the tropical equatorial regions of three continents, *i.e.* Africa, South America and Asia, between 10° N and 10° S. However, it is also found as far South as Madagascar (21° S) and North as Senegal (16° N). West Africa is the original home of the main commercial oil palm species. It was first introduced to Malaysia as an ornamental plant in 1870 and later was developed into an agricultural crop. In 1917, the first commercial planting took place in Tennamaran Estate in Selangor, laying the foundations for the vast oil palm plantations and the palm oil industry in Malaysia. From the 1960s onwards, oil palm has expanded many folds to become an important industry in Malaysia. In 2015, Indonesia has the world largest oil palm planted area of over 9 million hectares follow by Malaysia at over 5 million ha. Other countries with significant oil palms are Nigeria, Thailand, Pupua New Guinea, Colombia, Brazil, Cote d'Ivoire, Ecuador, Costa Rica, Cameroon, Congo and Ghana.

Palm oil is an edible vegetable oil extracted from the mesocarp (reddish pulp) of the oil palm fruits, primarily from the African oil palm (*Elaeis guineensis*), and to a lesser extent from the American oil palm (*Elaeis oleifera*) and the maripa palm (*Attalea maripa*). Its generic name "*Elaeis*' means "oil" in Greek on account of its fruits rich in oil. The species name, "guineensis" refers to the area of first scientific identification in Guinea.

Palm oil has wide uses ranging from food to biodiesel whereas oil from the kernel is a component of food, soap and oleochemical products. For every 100 kg of fruit

bunches, typically 25 kg of palm oil and 1.6 kg of palm kernel oil can be extracted.

CLIMATE and SOIL

Oil palm is grown commercially in more than 20 countries. These countries are located in the humid tropics within 10° N and S of the Equator. Suitable climate is important for its successful cultivation. The main climatic factors affecting its growth and oil production are:

1) solar radiation - sunshine hours exceeding 5 hours per day (or 1825 hours per year); 7 hours per day of sunlight is most suitable
2) rainfall - 2000 to 2500 mm per year evenly distributed; no dry month having less than 100 mm
3) temperature - thrives in areas with annual mean temperature between 24° C and 28° C; for high production, mean maximum temperature should be 29-30° C and mean minimum temperature about 22-24° C

Oil palm can grow on a wide range of soil types. However, the suitable soil must have good drainage and water holding capacity, and pH between 4 and 8, and no limitation to root development. It must also have high fertility, inherent or artificially created. Irrigation is generally not practised, but can increase FFB yield up to 40 tonnes per ha per year in dry areas.

BOTANY

Fruits and Seeds

As in many palms, fruits are drupes, fruits range in size from 2.5 cm to 5 cm, and are obovoid in shape (egg-shaped and solid). The mesocarp, from which palm oil is derived, is fibrous and oily, and the seed (endosperm) is opaque white, encased in a brown endocarp. Palm kernel oil is derived from seeds. The wild oil palm groves of Central and West Africa consist mainly of a thick-shelled variety with a thin mesocarp, called *dura*. *Dura* oil palm was imported and planted in the Far East in the 19th century. Breeding work, particularly crosses between *dura (DD)* and a shell-less variety *pisifera (dd)*, have led to the development of a hybrid with a much thicker mesocarp and a thinner shell, termed *tenera (Dd)*.

All commercial planting programmes now use this latter type, the fruits of which have a much higher content of palm oil than the native *dura*. The exocarp or epicarp colour is green changing to orange at maturity in virescens types. In the nigrescens types, the colour is deep violet to black at the apex and colourless at the base before ripening, but changing to orange red at ripening. The female inflorescence contains few hundreds to several thousand flowers, and fruit set is 50-70%. Fruit ripen about 5-6 months after pollination. The oil palm seed (2 - 4 cm) or nut is what remains after the oily mesocarp has been removed. It consists of a hard shell and in most cases one kernel, although two or three kernels may also be encountered.

Seedlings

Natural germination of oil palm seeds is slow and uneven. Volunteer oil palm seedlings growing in the fields are not suitable for commercial planting. In plantations, seedlings are raised from germinated seeds (high quality *DxP* seeds) by planting them in polybags for 10 to 12 months before field planting.

Fronds

The oil palm has only one growing terminal shoot. In mature palm, a new leaf primordium is produced every 2 weeks and becomes fully developed after 2 years. The crown of the palm may carry as many as 50 unopened leaves. The fronds of young mature palm are pinnate and reach between 3-5 m long. A young palm produces about 30-40 leaves a year. Established palms over 10 years old palms produce at least 20 leaves a year.

Optimum number of green fronds at planting density of 138-148 palms/ha	
Palm age (years)	Number of fronds
1 - 3	Maximum number present
4 - 8	45 - 48
8 - 12	40 - 45
> 12	38 - 40

The new unopened frond is known as the spear. On average, about 24 - 26 fronds are produced in a year. In accordance to their positions in the canopy, the fronds are named upper fronds, middle fronds, lower fronds, and dry hanging senescent fronds. The petiole, up to 1 m long, is marginally spiny and toothed.

Fronds (leaves) are numerous, erect, spreading to drooping, long, reaching 3-5 m in adult trees; leaf stalk with pinnae is known as rachis and the broad basal section is known as petiole. Fronds of tall palms reach up to 7-8 m in length, with pinnae (leaflets) numbering 200-300 per leaf, about 1-1.2 m long and 0.45-0.60 m wide. Pinnae (leaflets) cover the distal 2/3 of the leaf, and the lower 1/3 is spined with spines increasing in length acropetally. The long pinnae with prominent midribs, tapered to a point; arranged in groups or singly along the midrib, arising sometimes in different planes. The fronds are arranged in spirals. If the spiral of eight ascends the palm in clockwise direction, the palm is said to be left handed. If it ascends the palm in anti-clockwise direction, the palm is said to be right handed.

Flowers / Inflorescence

The flowers are produced in dense clusters and termed inflorescence. Each individual flower is small, with three sepals and three petals. The male flower is borne on a long peduncle and consists of long finger-like cylindrical spikelets, each of which comprises 600-1200 male flowers. Most pollen is shed within 2-3 days after the beginning of anthesis and production ceases within 5 days. Oil palms are monoecious (male and female flowers occur separately on the same plant), producing male and female inflorescences in leaf axils. The inflorescence of both sexes is a compound spadix with 100-200 branches, initially enclosed in a spathe or bract that splits 2 weeks prior to anthesis. There are distinct alternating female and male flower phase resulting in indefinite sexual phases.

Fruit Bunches

Oil palm produces compact fruit bunches weighing between 10–25 kg with 1000 to 3000 fruits per bunch. Fruits develop as early as just 2-3 years old, they appear fleshy, much like small plums, 2-3 cm long, oblong-ovoid in shape, reddish, crowded together in large clusters known as bunches, weighing 3-15 kg (from young mature palms). The fruit bunch of tall mature palms can weigh up to 40–50 kg or more.

The palm fruit takes 5 to 6 months to mature from pollination.

Each fruit is made up a single seed, which is also rich in oil. The fruit consists of a

hard kernel (seed, endosperm) within a shell (endocarp) which in turn is surrounded by a fleshy mesocarp. The mesocarp and karnel are each made up of about 50% oil (range 40-60%).

Composition of oil palm fruit bunch	
Bunch weight	23 - 27 kg
Fruit/Bunch	60 - 65 %
Oil/Bunch	21 - 23 %
Kernel/Bunch	5 - 7 %
Mesocarp/Bunch	44 - 46 %
Mesocarp/Fruit	71 - 76 %
Kernel/Fruit	21 - 22 %
Shell/Fruit	10 - 11 %

Stem

The African oil palm resembles the coconut palm (*Cocos nucifera*), and has a single erect stem, which can reach up to 25-30 m tall. The stem or trunk is characterized by persistent, spirally arranged leaf bases and bears a crown of 20-40 massive leaves. When the fronds (leaves) are cut during pruning rounds or harvesting, the portion of leaf bases left attached are termed frond butts. Up to about 12-15 years of planting, the trunk is fully covered with frond butts. On old tall palms, these frond butts are detached and the trunk appears markedly ringed and the scars occupy large portion of the stem surface. The base of the trunk is usually larger and referred to as basal stem. The portion of the trunk below the ground is sometime named the root bole.

Roots

Roots arise from the hypocotyls and later from the basal bole of the stem. The root system consists of primaries and secondaries in the top 140 cm of soil.

There are four types of roots in oil palm, namely primary roots, secondary roots, tertiary roots and quaternary roots, the last two being commonly called feeder roots. Primary roots (8-10 mm in diameter) are mostly horizontal although some grow downwards for anchorage. Secondary roots (2-4 mm in diameter) arise from the primary roots and mostly grow horizontally upwards towards the soil surface. Tertiary roots (1.5 mm in