GROWTH AND PRODUCTION OF OIL PALM

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Contents

1. Introduction
2. Origin and Distribution
3. Botany
3.1. Cultivars and Classification
3.2. Structure
3.3. Pollination and Propagation
4. Ecology and Growing Conditions
4.1. Climate Requirements
4.2. Soil Requirements
5. Land and Crop Husbandry
5.1. Land Clearing
5.2. Planting and Land Management
5.3. Pests and Diseases
5.3.1. Nursery Deficiency Diseases
5.3.2. Nursery Pests
5.3.3. Nursery Diseases
5.3.4. Field Pests
5.3.5. Field Diseases
5.4. Crop Forecasting
5.5. Harvesting
6. Milling and Oil Processing
7. Utilization and Use
8. Production and Trade
9. Future Perspectives for Oil Palm Production
Glossary
Bibliography
Biographical Sketch

Summary

Oil palm is a tropical tree crop which is mainly grown for the industrial production of vegetable oil. For optimal growth and production the crop requires a high and year-round rainfall with little or no dry season and stable high temperatures; soils should be deep and well drained. The crop grows mainly in tropical lowlands below 400m altitude, originally covered by a dense rainforest. Dry spells or temperatures below 18° C do not affect vegetative growth but reduce yield. Fertilizer demands are moderate

compared to other industrial crops and are mainly for compensating the nutrients harvested in the fruit bunches.

The crop is sensitive to many pests and diseases. As those affect quite seriously yield and economic profit, estate managers should pay due attention to control and/or eradication of such pests and diseases.

Oil palm is now the most important supplier of vegetable oil in the world. There are 3 oil palm varieties: *Dura*, *Pisifera* and *Tenera*, with the latter being mainly selected for economic production. The oil is concentrated in the fruit bunches, composed of a fresh fruit pulp, and in the fruit kernels. Oil content in the fruit pulp is about 50-60% or 20-22% of bunch weight; oil content in the fruit kernels is 48-52% or 2-3% of bunch weight. Fresh fruit bunches once harvested must be treated in an oil mill within 24 hours to avoid that oil quality decreases.

Palm oil has for a long time been considered a relatively low-value edible oil because of the difficulty in manipulating its fatty acid profile. Recent research has gradually upgraded this perception, and palm oil is now becoming a high-value niche product in the health food sector.

1. Introduction

Oil palm (*Elaeis guineensis*) is a tropical tree crop which is mainly grown for its industrial production of vegetative oil. It is a typical estate crop, grown and harvested over large uniform areas (3,000 to 5,000 ha) around a central oil mill to allow rapid industrial handling after harvesting. Palm trees can also be observed in village gardens where they provide oil for local consumption, but in that case both yield and oil quality are much lower.

Oil palm is a typical crop of the rainy tropical lowlands. The tree requires a deep soil, a relatively stable high temperature and continuous moisture throughout the year. Soil fertility is less important than physical soil properties. Dry periods of more than 2-3 months do not specifically damage vegetative growth, but affect seriously the production and quality of the fruit bunches. Oil palm yield is not only determined by vegetative growth and production, but also by the way and pests and diseases can be controlled or eradicated.

Because industrial oil palm plantations need the clearance of large areas they often require the expropriation of land and the cutting of extensive (pristine) forest areas. Hence, the development of such plantations is usually associated with land tenure conflicts and problems of local land ownership on one hand and ecological problems, viz. biodiversity loss, on the other hand.

2. Origin and Distribution

The origin of oil palm points to Africa, in particular to West Africa. Fossil pollen, similar to the oil palm as it grows today, have been found in Miocene and more recent strata in the Niger delta. Portuguese explorers of the Guinea coast mention the existence of trees appearing to be oil palms as early as 1434. In 1508 already reference has been made to palm groves in Liberia, and to palm oil trade near the Forcados River in Nigeria. Later, Portuguese, Dutch and English travelers refer to palm wine and palm oil in the area.

The centre of origin of oil palm is the West and Central African coastal belt between Guinea and northern Angola. The palm spreads from 16° North in Senegal to 15° South in Angola, and eastwards to Zanzibar and Madagascar. The best production levels are attended in the high rainfall areas between 7° North and South from the Equator.

Oil palms are sporadically encountered up to St. Louis in Senegal and to the Upper Niger valley near Bamako. Minor palm groves are observed around Dakar and in the Gambia, but their production is too low to justify the establishment of commercial oil mills. The real palm belt in Africa runs through the southern latitudes of Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon and into the equatorial regions of Equatorial Guinea and the Congo. The northern limit of this belt varies with the isohyets of 1200mm rain per year and with the topography of 400m altitude. There is a small area surrounding Accra where due to low rainfall (less than 650 mm/year), oil palm estates are absent.

The extension of oil palm in East Africa is irregular. Most of East and South-East Africa is too dry and, therefore, the crop appears only at altitudes below 1,000m near lakes or watercourses with reasonable rainfall. Its presence on the eastern coast of Madagascar is due to a local microclimate, though in this area the crop can be affected by tornados.

In the Far East palms were initially only grown as ornamental plants. Seed selection in the Botanic Gardens of Singapore and Bogor (Java, Indonesia) and at the Deli Research Center in Sumatra (Indonesia) gave origin to an important development and extension of the crop since the 1930s in Malaysia and Indonesia. These are now the main production areas in the world, both in terms of palm oil and palm kernel production (Table 1). The yield and quality of palm oil produced in these areas is still superior to the oil produced in other parts of the world. Oil palm plantations in Latin America are relatively recent.

	Palm oil production (x 1000 tons)				**Palm kernels production (x 1000 tons)**			
	1969-71	1980	1990	2002	1969-71	1980	1990	2002
World	1983,034	5052,641	11163,308	-	1178,651	1812,081	3511,624	7059,000
Africa	1108,647	1365,350	1683,454	-	731,005	733,927	672,208	1018,000
S. America	46,752	134,759	505,660	-	248,489	330,549	325,701	312,000
Asia	769,583	3461,300	8687,410	-	177,683	730,405	2420,034	5520,000
Cameroon	63,400	79,000	108,000	144,000	40,737	46,000	42,00	67,000
Ghana	19,330	21,000	85,000	108,000	36,000	30,000	29,000	36,000
Guinea	42,600	42,000	50,00	50,000	35,000	35,000	40,000	53,000
Ivory Coast	46,467	170,000	207,714	216,000	19,333	30,000	36,800	40,000

Liberia	14,233	27,000	30,000	42,000	14,443	7,200	7,000	11,000
Nigeria	528,330	675,000	820,000	908,000	287,100	345,000	356,000	608,000
Sierra Leone	46,467	48,000	55,900	36,000	60,100	30,000	26,800	22,000
Congo	232,433	108,300	180,000	170,000	99,100	69,300	74,000	81,000
Brazil	7,166	16,000	65,000	118,000	218,599	265,988	229,000	120,000
China	114,333	190,000	133,000	220,000	28,333	48,000	33,500	56,000
Indonesia	217,900	676,800	2186,210	9350,000	48,980	121,105	477,824	2053,000
Malaysia	457,298	2573,000	6094,700	11909,000	98,996	557,000	1844,700	3269,000
Philippines	2,017	12,000	45,000	56,000	367	2,400	14,000	16,000
Thailand	-	9,500	226,000	590,000	-	1,900	50,000	126,000

Table 1. Palm oil and palm kernel oil production in the world
(Sources: FAO Yearbooks and http://www.unctad.org)

3. Botany

The oil palm tree (*Elaeïs guineensis*) is a member of the family *Palmae*, subfamily *Cocoideae* (which also includes the coconut), genus *Elaeis*. The genus contains two main species: *E. guineensis* or African oil palm, and *E. melanococca* or American oil palm; the latter is only valuable for hybridization. Male and female inflorescences occur on the same tree in alternated cycles of the same sex, and are only differentiated after approximately two years. This process is influenced by moisture and temperature conditions, fertilization and other secondary ecological factors.

The development of the inflorescence to the fruit regime takes 42 months, including 10 months from establishment to initial sexual differentiation, 24-26 months between sex development and flowering, and 5-6 months from flowering to yield. Hence, ecological conditions which affect earlier phases of inflorescence and flowering appear only in the yields 18 to 24 months afterwards. This situation opens good perspectives for good yield forecasting (see Section 5.2).

3.1. Cultivars and Classification

Cultivars in the strict sense do not occur. As the oil palm is monoecious and cross-pollinated, individual palms are usually very heterozygous; and vegetatively propagated clonal material can not be made. The current classification of cultivars is mainly based on fruit structure and yield (or commercial value):

- *Macrocaria*: shell (endocarp) 6-8mm thick; is an extreme form of *Dura*, which is still widely spread in Sierra Leone and western Nigeria; without any commercial value;

- *Dura*: shell 2-8mm thick, comprising 25-55% of weight of fruit, medium mesocarp content of 35-55% by weight, but up to 65% in Deli palms; less productive but hardy variety, well adapted to village gardens;

- *Pisifera*: shell-less, with small pea-like kernels in fertile fruits; of little commercial value, because of its high abortion ratio, but important for cross-breeding commercial palms; and

- *Tenera:* shell 0.5-3mm thick; comprising 1-32% of weight of fruit; medium to high mesocarp content of 60-95%, but occasionally as low as 55%; this variety is the result of a hybridization of *Dura* and *Pisifera*, and has a high commercial value.

Most commercial plantations are established on the basis of *Tenera* palms. Oil palms may live up to 200 years, but their commercial yield rapidly decreases after 30 years of age (Figure 1).

Figure 1. Oil palm plantation of about 12 years old. The stipe is covered by old bases of leaves which were cut during harvesting and maintenance pruning (Courtesy D. Cornet).

3.2. Structure

Oil palm is an un-branched, 20 to 30m high tree. *Roots* arise from the base of the hypocotyl and later from the basal bole of the stem. Primary roots descend deeply from the base of the trunk, but remain short when the water table is high. Otherwise they produce secondary, tertiary and quaternary roots that form a dense mat in the immediate neighborhood of the tree. Most roots are found in the top 15cm of the soil, with a main concentration near the palm and a secondary concentration 1.5 to 2m from the base.

The early growth from the seedlings results in the formation of a wide *stem* (*stipe*) base. A trunk is not formed until 3 years old when the apex has reached its full diameter in the form of an inverted cone, after which intermodal elongation takes place. The rate of extension then depends on environmental and hereditary factors, and varies between 25 and 50cm per year.

The *leaves* are produced in spiral succession from the meristem. The crown consists of 40-50 opened leaves in various stages of development. One leaf is produced per month until the seedling is 6 months old. The number of leaves produced increases to 30-40 per year at 5-6 years old and later declines to 18-25. The life of a mature leaf after unfurling is about 2 years. The leaf area of an adult palm is around 400 m² (Figure 2).

Flowering starts after the young palm has well established (Figure 3). An inflorescence primordium is produced in the axil of each leaf at the time of leaf initiation. The inflorescence reaches the central spear stage in two years and a further 9-10 months is required to flowering and anthesis. Each flower primordium is a potential producer of male and female inflorescence (see sex ratio below). The number of inflorescences per palm depends on the number of leaves produced and the number of inflorescences which reach maturity without abortion.

Figure 2. Young oil palm of three years old; note the cover crop (*Pueraria*) in the interrow (Courtesy D. Cornet)

Inflorescences - Male and female inflorescences form separately on the same palm. A male inflorescence produces 10-40g of pollen, i.e. millions of grains. A female inflorescence consists of a central stalk (peduncle) to which spikelets are attached. On these spikelets one finds the tiny 1 cm-diameter cream-colored female flowers.

Sex ratio - The proportion of female to total inflorescences, must be high to obtain high yields, but the order and proportion of male and female inflorescences shows little regularity. The period between sex differentiation and anthesis is about 2 years. The sex ratio is partly genetic and partly determined by climatic and other environmental conditions at the time of floral determination.

Fruiting and harvesting - The time from flowering to harvesting of ripe fruits is 5-6 months. The fruit bunch is tightly wedged in the leaf axil of the palm. A bunch of a mature palm contains 1,000 to 4,000 fruits, depending on the tree’s age and vigor. A bunch weights at maturity 15-25kg, but can occasionally reach over 50kg (Figure 4).

The percentage of fruits per bunch is usually 50-65% and is lower in Tenera than in Dura due to the thicker shell of the latter. The egg-shaped fruits weigh 10-20g. The pulp (mesocarp) around the nut contains the red palm oil. The kernel in the nut contains oil very similar to coconut oil, but palm oil and palm kernel oil are chemically different.

Figure 3. Elaeis guineensis (Purseglove, 1976).
(A: Palm tree; B: portion of leaf rachis; C: base of rachis; D: male inflorescence; E: male spike; F: male spike in transverse section; G: male flower in longitudinal section; H: portion of female inflorescence; I: female flower; J: fruit bunch; K: fruit; L: fruit in longitudinal section).

Figure 4. Fresh fruit bunch (Courtesy D. Dewaele)

3.3. Pollination and Propagation

Oil palms are cross *pollinated*. Pollen are dry and are mainly wind-born over at least 30m. Male flowers are anise-scented and are visited by insects, particularly bees, but these do not visit the male flowers. Assisted pollination is given in modern plantations in order to increase yields.

Naturally distributed seeds do not germinate readily, and while awaiting favorable seasonal conditions, many of them might be destroyed by rodents or boring beetles. In West Africa they remain often dormant during the dry season and start germinating 6-10 weeks after the start of the first rains.

A high temperature is required for satisfactory germination: 30-40° C for 80 days at a moisture content above 14.5%, followed afterwards by ambient temperatures and moisture contents of 21-22% (for *Dura*) or 28-30% (for *Tenera).*

Seeds can be stored for at least a year at ambient temperatures. Germinated seeds, transported in polythene bags or packed in boxes, can remain in the bags for up to ten days before planting. Germinated seeds are planted in pre-nursery beds, trays, baskets or bags. After 4-5 months, when the seedlings reach the 4-5 leaf stage, they are transferred to field nurseries or large polythene bags where they grow for 6-12 months before transplanting to the field.

4. Ecology and Growing Conditions

Oil palm is a typical tree crop of the tropical rainforest. It can however hardly survive or regenerate in dense secondary forest because of the lack of sunshine. This is also the reason why stand-alone trees in villages are generally much taller than in palm groves. For optimal growth and production the tree requires stable climatic conditions, in particular with respect to light and moisture supply. Any deviation from these conditions enhances a yield decrease.

Oil palm thrives best in lowlands below 300-400m altitude. Under a favorable microclimate it can also occur at much higher altitudes, as is the case on Mount Cameroon, where palms are observed up to 1,300m elevation, or in the Fouta Djalon area in Guinea. In East Africa palm trees can be found at altitudes up to 1,000 m.

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Biographical Sketch

Willy Verheye is a former, now retired Research Director at the National Science Foundation, Flanders, and a Professor in the Geography Department, University of Ghent, Belgium. He holds an MSc. in

Physical Geography (1961), a PhD. in soil science (1970) and a Post-Doctoral Degree in soil science and land use planning (1980).

He has been active for more than thirty-five years both in the academic world, as a professor/ research director in soil science, land evaluation, and land use planning, and as a technical and scientific advisor for rural development projects, especially in developing countries. His research has mainly focused on the field characterization of soils and soil potentials, and on the integration of socio-economic and environmental aspects in rural land use planning. He was a technical and scientific advisor in more than 100 development projects for international (UNDP, FAO, World Bank, African and Asian Development Banks, etc.) and national agencies, as well as for development companies and NGOs active in inter-tropical regions.

W. Verheye is the author or co-author of more than 100 peer reviewed papers published in national and international journals, chapters in books and contributions to the Encyclopedia of Life Support Systems (EOLSS). He is Honorary Theme Editor for the EOLSS, Theme 1.5: Crops and Soil Sciences.