

Reading 24

Palmae

Elaeis guineensis Jacq.

Vernacular names: Oil palm (En); palmier a huile (Fr); Indonesia: kelapa sawit.

Origin and Geographic Distribution

Oil palm is native to Africa and it is assumed that speciation took place in that continent. However since all related species classified in the subfamily Coccoideae have a South American origin (except perhaps the coconut, *Cocos nucifera*), the archetypal ancestor may have been indigenous to the Americas.

Oil palm occurs in palm groves throughout the tropical rain-forest belt of West Africa between 10°N and S of the equator. However most of these groves show signs of human interference and probably owe their origin to man. Oil palm has played a major role in the village economy throughout West Africa for many centuries.

Oil palm was introduced to South America with the slave trade. In fact the original description of Jacquin in 1763 was based on a specimen growing in Martinique. Semiwild groves are reported in coastal regions of Brazil around Belem. The oil palm was introduced into South-East Asia in 1848 through the Botanical Garden of Bogor, Indonesia. Second-generation and third-generation descendants from the originally introduced material have been used as planting material for the first oil-palm estates in Sumatra (since 1911) and Malaysia (since 1917) and have given rise to the Deli Dura breeding population.

Uses

The oil-palm fruit yields two types of oil: palm oil from the fleshy mesocarp, and palm kernel oil from the kernel, in the volume ratio 10:1. The two oils differ in composition and properties and, consequently, find rather different applications.

Ninety percent of all palm oil is used in foods. In South-East Asia, the preferred oil for domestic consumption is a clear liquid oil. For domestic use, the liquid fraction palm olein is satisfactory, provided the ambient temperature is above 20°C. Main uses of exported palm oil are margarine, fat used in pastry production and in industrial frying of potato chips, instant noodles and snack foods. Fractions of palm oil are useful in confectionery. Palm stearin, the solid fraction of palm oil, is increasingly used in soap manufacture. Palm-derived fatty acids, mainly commercial grades of stearic and palmitic acids, form an alternative to the traditional products based on tallow.

Palm kernel oil is a lauric-type oil similar in composition and properties to coconut oil. In Malaysia, increasing proportions of the palm kernel oil are fractionated or hydrogenated for use in confectionery, where the higher melting products are particularly useful. In Indonesia, palm kernel oil is used for local consumption, often in blends with palm olein. Palm kernel oil is also used for industrial purposes, either as an alternative to coconut oil in the manufacture of high quality soaps, or as a source of short-chain and medium-chain fatty acids. These acids are chemical intermediates for the manufacture of fatty alcohols, esters, amines, amides and more sophisticated chemicals, which find a multitude of end-uses, for instance in surface-active agents, plastics, lubricants and cosmetics.

The utilization of oil-palm byproducts is currently the subject of research. Various waste streams from the palm-oil mill have been proved to have value as fertilizers, feedstuffs or fuel.

Reading 24

The African practice of producing palm wine from the exudate of male inflorescence stalks has not been adopted in Asia. Palm fronds are less suitable for thatching since leaflets on the two sides of the rachis are inserted at two angles. Palm trunks, available at replanting, provide excellent material for paper and board production. However this has not so far been put into commercial practice.

Economic & Production Data

The oil palm is a major oil crop, taking second place in world supply of vegetable oil after soya bean. The following data are based on 1982 statistics of FAO. Between 1970 and 1982, world palm-oil production increased from less than 2 million tonnes to over 6 million tonnes and still is rising rapidly. South-East Asia is the main area of production, with 76% of the total world palm-oil production. By country, production of palm oil in 1982 was for Malaysia 3.5 million, Indonesia 874,000, Philippines 13,000, Papua New Guinea 77,000 and Thailand 24,000 tonnes.

Malaysia dominates the palm-oil market with over 60% of the world production and supplies 80% (about 3 million tonnes or 90% of the country's production) of the export market. The total area under oil palm is 1,226,500 ha with 66,000 ha in Sabah and Sarawak. Traditionally, plantation companies play a major role with 645,700 ha. However government smallholders schemes increased their share with 356,000 ha planted in 1982.

Palm-oil production in Indonesia is increasing steadily if less spectacular than in Malaysia with 365,885 ha planted in 1982, primarily in state-owned plantations (259,281 ha) and private estates (100,676 ha). Only 30% of the Indonesian palm oil is exported. The domestic market is a main outlet where it supplies 48% of the total vegetable oils.

In Papua New Guinea, oil palm is important to the national product but in absolute amount is of minor importance. In the Philippines and Thailand, oil palm is still a minor crop though interest and potential for expansion is present.

Properties

The main components of palm oil are palmitic (47–52%), oleic (34–41%), and linoleic acids (6–9%). Other fatty acids rarely form more than 2–5% of the total acid content. In palm oil, saturated palmitic acid and mono-unsaturated oleic acid each accounts for 40% of the fatty acids present. Crude palm oil also contains nutritionally valuable carotenoids (450–820 mg/kg) and tocopherols (450–850 mg/kg) which, however, are reduced during refining to zero and about half the original value, respectively. Content of saturated fatty acids in palm kernel oil is 85%.

Description

A monoecious, erect, one-stemmed palm-tree, usually 20–30 m high. Root system adventitious, forming a dense mat in the upper 35 cm of the soil, with only a few roots penetrating deeper than 1 m. Stem cylindrical, up to 75 cm diameter, covered with petiole bases in young palms, smooth in older trees (10–12 years old). Juvenile leaves lanceolate, entire to gradually becoming pinnate; mature leaves spirally arranged, paripinnate, up to 7.5 m long; petiole 1–2 m long, spinescent, clasping the stem at base; leaflets linear, 35–65 cm × 2–4 cm. up to 376 per leaf. Inflorescences unisexual, axillary, pedunculate, until anthesis enclosed in 2 fusiform or ovate spathes 10–30 cm long, with flowers 3-merous; male ones with numerous cylindrical spikes forming an ovoid body 15–25 cm long and bearing flowers with 6 stamens, connate at base, with linear anthers; female ones subglobose, 15–35 cm diameter, with numerous lanceolate, spiny bracts, each subtending a

Reading 24

cylindrical spikelet with 10–20 spirally arranged female flowers, each with two rudimentary male flowers; stigma sessile, 3-lobed. Fruits ovoid-oblong drupes, 2–5 cm long, tightly packed in large ovoid bunches with 1000 to 3000 fruits; drupes with a thin exocarp, an oleiferous mesocarp and a lignified endocarp containing the kernel with embryo and solid endosperm.

Growth and Development

After harvesting, oil palm seeds are dormant. The physiology of this dormancy is not well known. Germination of seeds can be speeded up by dry heat treatment (40°C) for 80 days, followed by cooling at a higher moisture content. Seedlings are usually kept in poly-bag nurseries for about 12–14 months and planted in the field when they have 18–24 leaves. The stem has a single growing point, from which a leaf primordium develops about every second week. Succeeding primordia are separated by a divergence angle of 137.5° (Fibonacci angle), causing leaf bases to be arranged in various sets of spirals, of which a set of 8 parastichies is normally obvious. Rate of leaf production is up to 40 per year in the first two years, dropping to a rate of 18–24 per year from year 8 onwards. From leaf primordium to fully expanded leaf (2–10 m²) takes about 2 years. The normal photosynthetically active life of a leaf is about 2 years, so under natural conditions up to 50 leaves are present per palm. In plantations, this number is usually kept at about 40. In the first two years, lateral growth of the trunk dominates, giving a broad base up to 60 cm in diameter. After that, the trunk starts growing in height, 35–75 cm per year, reducing its diameter up to 40 cm. The rate of height increment and rate of leaf production appear to be independent. All leaf bases contain inflorescence primordia, but the first fully developed inflorescence does not appear before Leaf 20 and usually much later, some three years after germination. The length of male and female phases in individual palms is very variable and irregular, but a population of palms shows clear seasonal trends. The physiological basis of sex differentiation is not yet well understood, except that empirical evidence suggests that physiological stress conditions seem to encourage maleness. Pollination is primarily by insects. One of the insect vectors, *Elaeidobius kamerunicus*, was successfully introduced into Malaysia and subsequently Indonesia in 1979. Before that, oil palms in the region were wind-pollinated, often requiring artificial pollination in the first few years.

The mean interval between sex differentiation and anthesis is around 20 months and between anthesis of female flowers and fruit ripeness 4–5 months. Fruit ripening on the bunch proceeds simultaneously from top to bottom and from outer to inner fruits. Ripe fruits become detached.

Other Botanical Information

The genus *Elaeis* consists of three species: the African *E. guineensis*; and two species indigenous to South and Central America, (*E. oleifera* and *E. odora*). *E. guineensis* is the major economic species. Fruits of *E. oleifera* have a much lower oil content and are used only locally in its natural area of distribution. Little information is available on *E. odora*. A particular feature of the oil palm with considerable economic consequences is the occurrence of three natural fruit types under monogenic control, which form also the basis for the classification of oil palms.

- Dura: homozygous (sh+ sh+) for the presence of a relatively thick endocarp (shell 2-8 mm)
- Tenera: heterozygous (sh+ sh-) with a relatively thin endocarp (0.5–4 mm)
- Pisifera: homozygous (sh- sh-) for the absence of an endocarp

The original Bogor palms and material derived from them were the thick-shelled types and as a population is generally referred to as Deli Dura. Pisifera is usually female-sterile. The cause

Reading 24

of this sterility is still unknown but may be reduced protection of the developing embryo through absence of lignified endocarp tissue. Tenera is preferred as planting material because of more oil-bearing mesocarp (60–90% per fruit weight) than Dura (20–65% per fruit weight). Within each fruit type, there is considerable variation apparently under polygenic control.

Ecology

The natural environment oil palms is the lowland humid tropics. They thrive on a good moisture supply and open area as they cannot compete with faster-growing tree species. The oil palm does not grow under continuous flooding but is tolerant of fluctuating watertables with periods of standing water. Hence, the natural habitats are considered to be swamps, riverbanks and other areas too wet for dicotyledonous trees of tropical rain forest. Under cultivation, rainfall is often the main limiting factor for production. Major areas of oil palm cultivation are in the equatorial belt where mean annual rainfall deficits do not exceed 600 to 650 mm annually. Highest yields are achieved where rainfall is well distributed throughout the year with an optimum of 150 mm monthly. Little is known about temperature effects other than that oil palms grow less well at higher altitudes (above 500–600 m) and at higher latitudes (above 10°). In regions where minimum temperatures drop regularly for prolonged periods below 20°C, productivity and growth are severely reduced. The oil palm is also affected by high temperatures. Photochemical efficiency seems to be reduced above 35°C.

Oil palms can grow on a wide variety of soils ranging from sandy soils to lateritic red and yellow podzols, young volcanic soils, alluvial clays and peat soils. A major criteria for relative suitability seems to be the water-holding capacity. Since oil palms are responsive to soil nutrients, nutrient-release characteristics are also important as they affect the efficiency of fertilizer use.

Propagation

Traditionally the oil palm has been grown from seed. However in the late 1970s, tissue-culture techniques were developed for vegetative propagation and in the mid 1980s vegetatively propagated clonal oil-palm material became available for commercial planting. Seedlings are grown in polybag nurseries for 12–14 months with the obvious requirements for good soil, regular water supply and modest amounts of nutrients applied at frequent intervals. For transplanting into the field, dry periods should be avoided.

The development of tissue-culture techniques for vegetative propagation is a major breakthrough in oil-palm cultivation. Scaling up of production processes is making progress and clones are expected to become the main source of planting material in the 1990s in South-East Asia. Vegetative propagation does not alter selection objectives but should accelerate progress by allowing effective selection for more characteristics simultaneously like yield, harvest index, tolerance for competition, rate and uniformity of fruit ripening within bunches. First results of selected clones suggest a yield increment of 15–20% over good seedling material.

Husbandry

Planting density is a major issue as it determines competition between palms for light, water and minerals, with competition for light seemingly the major factor. It has been observed that when competition between palms reduces the amount of dry matter produced per palm, amount of dry matter used for vegetative growth is less affected than the amount used for fruit bunches. Hence maximum yield of oil is reached at a planting density that is lower (140–160 per ha) than the den-

Reading 24

sity that gives maximum total dry matter production. Generally at field planting, a leguminous cover is established to protect the soil, provide humus, add to the nitrogen supply and suppress weeds. Harvesting paths are kept open and clean weeding is practised around palms to prevent competition from the cover crop and to facilitate loose fruit collection. Otherwise spot weeding is applied for general maintenance. During harvesting of bunches, fronds are usually removed as well. If the number of leaves per palm drops below 35, yield declines. Hence the aim is to maintain number of leaves at 35–40, which comes close to a minimum pruning system.

Considering the importance of moisture supply, it may be assumed that oil palms would benefit from irrigation. However so far, there have been no reports on the use of irrigation on a plantation scale.

Nutrient requirements have been studied intensively. Uptake and use are very much affected by various environmental conditions. Considerable use is made of foliar analysis as a diagnostic tool for nutrient status combined with local specific field trials. Generally nitrogen and potassium show significant interactions, with nitrogen being the key element. Although single responses to phosphorus and magnesium are rare, including these at maintenance levels, especially for phosphorus, often give linear responses. On plantations in Malaysia on poor red and yellow podzols, amounts of 2–4 kg nitrogen and 1.5–3 kg potassium applied per palm annually are not uncommon. On the nutrient-rich young volcanic soils of parts of Sumatra, requirements are of course much less. Information on the need for micronutrients is less well established in oil palm. There are well documented cases of boron deficiency. On peats, there are suspected cases of copper deficiency cured with copper sulphate. Adequate sulphur and chlorines are usually applied as compounds of nitrogen and potassium.

Pruned leaves are generally stacked between rows, providing a source of mulch together with the ground cover. As the canopy closes, the legume cover is gradually replaced by a natural cover, often consisting of a mixture dominated by various grasses and ferns. The oil palm is a fairly labour-intensive crop, requiring about one labourer for 4 ha. The need for increased mechanization of field operations becomes evident in a number of regions with a labour shortage such as Malaysia. However as a crop, it is not easy to mechanize.

Diseases & Pests

The oil palm in South-East Asia is remarkably free of pests and diseases. Occasional outbreaks of bagworms (*Psychidea*), and nettle and slug caterpillars (Limaconidae), notably in Sabah, Sumatra and the Philippines, are easily controlled by a policy of minimum insecticidal intervention. The rhinoceros beetle (*Oryctes rhinoceros*) has readily adapted to the oil palms. Destruction of breeding sites and good ground cover generally ensures adequate control. Other insects occasionally cause some damage like *Thirathaba mundella* (oil-palm bunch moth), some root-feeding cockchafers, *Valanga nigricornis* (a grasshopper) but are only a minor problem. Of the few diseases, *Ganoderma* causes locally high losses, especially when coconut areas are replanted with oil palms. Infection takes place through contact with infected dead root tissue. Several diseases are observed in the nursery: brown germ *Curvularia* leaf spot, blast (*Pythium* and *Rhizoctonia*). However all are easily controlled by both cultural and fungicidal treatments.

Harvesting

Under normal conditions of plantations, harvesting of bunches generally starts about 2½ years after field planting. Bunches ripen throughout the year and harvesting takes place in rounds at

Reading 24

intervals of 2 or 3 weeks in any particular area. Bunches are cut that have reached an agreed standard of ripeness, usually expressed in number of detached fruits per bunch. They are cut from the stalk with either a chisel or a so-called 'Malayan knife', consisting of a sickle on a long bamboo or aluminum pole. So far, cost has defied more mechanized forms of harvesting. Bunches are transported to collection sites along the road and from there direct to the factory.

Yield

The oil palm is extremely responsive to environmental conditions and yields therefore show great variation. The course of yield over time, however, shows a clear trend, rising to a maximum in the first few years (6–8 years after planting in the field), usually declining slowly thereafter. In well managed plantations in Malaysia and Sumatra, on soils with a reasonable availability of nutrients and a good water-holding capacity under uniform and adequate rainfall, yields of bunches of 24–32 t/ha are common. At the factory, extraction rates of oil with reference to bunch weight are 20–22%; this represents oil yields of 4.8–7 t/ha, which is higher than in any other oil crop.

Handling after Harvest

Bunches are sterilized with steam under pressure to arrest breakdown of oil to fatty acids and to detach fruits from the bunch. Oil is removed from the mesocarp in mechanical presses; fibre and nuts are separated; kernels are removed from the nuts. Crude oil undergoes several purification procedures (static settling centrifugal purification and drying) before it enters manufacture. Desirable qualities in palm oil are low content of free fatty acids (FFA), low impurities, low moisture content, a low degree of oxidization, good oxidative stability, good bleachability and consistency of all properties.

Kernels are usually extracted in separate milling units, either in the country or abroad.

Genetic Resources

In common with several plantation crops in South-East Asia (notably rubber, cocoa, coffee, tea, cinchona), the genetic origin of the commercial material is rather narrow and to some extent almost accidental. The oil-palm industry in Indonesia and Malaysia started with material descended from four palms (thick-shelled dura) introduced in the 19th Century in the botanical garden of Bogor (Indonesia). Their simultaneous introduction (probably from Mauritius or Réunion) suggests that the four seeds may well have derived from a single (open-pollinated) fruit bunch. Seeds of these palms and their descendants were widely distributed throughout Indonesia as ornamental palms. Avenue palms in Deli (North Sumatra) supplied the seeds for the first oil palm estates from 1911 onwards. In Malaysia, the first estate was established in 1917. By the early 1920s, a number of breeding and selection programmes started, which caused improved planting material generally referred to as Deli Dura. Until the 1950s, Deli Dura was used exclusively as planting material in both Indonesia and Malaysia.

Elucidation of single-gene inheritance of shell thickness caused interest in the Tenera fruit type (sh+ sh-) as commercial material obtained from a cross of Dura (sh+ sh+) with Pisifera (sh-sh-). Material segregating for the shell-thickness gene descending from a single Tenera palm (SP 540) in Sumatra was a major source of Pisifera for several breeding programmes. This palm probably has a common origin with material in the breeding programme at Yangambi (Zaire), descending from nine Tenera palms. By the 1960s, major breeding programmes in Sumatra and Malaysia concentrated primarily on Deli Dura and 'Yangambi' Pisifera for production of commercial plant-

Reading 24

ing material. Since then, extensive new introductions have been effected from various breeding programmes in West Africa (Ivory Coast, Nigeria, Cameroon, Zaire). In the late 1970s and early 1980s, the Palm Oil Research Institute of Malaysia (Porim) has started a systematic programme of prospecting and collection from oil groves in West Africa and of *E. oleifera* populations in South and Central America, widening significantly the basis for breeding programmes.

Breeding

Oil-palm breeding has progressed from simple mass selection (progenies and individual palms within progenies) to various forms of recurrent selection for Dura and Pisifera that give high-yielding Tenera.

It was estimated that in the first generation selection in Deli Dura, a relative increase in yield of 20–24% was realized, followed in the subsequent 2–3 generations by improvements of 10–12%. The change-over in the 1960s from Dura to Tenera gave an immediate yield increase of up to 20% (the proportion of oil in bunch increased from 16–18% in Dura to 20–22% in Tenera).

In Malaysian programmes, considerable attention is directed to components of growth in an effort to improve harvest index, reduce height increment and increase optimum planting density and so to increase oil yield.

Prospects

The prospects for the oil palm appear bright. The demand for vegetable oils is rising as standard of living increases in parts of the Third World. As a crop, it is better suited than annual food crops to most soils prone to leaching in the humid tropics. It provides continuous ground cover and ecological conditions similar to the original forest vegetation. Also further increases in yield may be expected. Extrapolations from crop-growth models suggest that the physiological potential for oil yield of the oil palm may well be 12–14 t/ha against maximum yields of 6 t/ha in 1986. The new possibility of clonal propagation is an important factor in this respect.

Forecasts for Malaysia are that total production of palm oil will reach 6 million tonnes by 1991, leveling off at around 6.2 tonnes. The potential for Indonesia may be even larger because of available land resources and expected relatively lower costs of labour.

In most countries with a suitable climate, oil palm cultivation is expanding. The main drawback of the oil palm is the difficulty of mechanization, notably of harvesting operations, in a cost effective manner. Hence, availability and cost of labour may well become the main limiting factors.

Literature

Corley, R.H.V., Hardon, J.J. & Wood, B.J. (Editors), 1976. Oil palm research. Elsevier Scientific Publishing Co., Amsterdam. 532 pp.

Hardon, J.J., Rao, V. & Rajanaidu, N., 1985. A review of oil-palm breeding. In: Russell, G.E. (Editor). Progress in plant breeding 1. Butterworths, London. p. 139–163.

Hartley, C.W.S., 1977. The oil palm. 2nd edition. Longman, London. 806 pp.

Turner, P.D. & Bull, R.A., 1967. Diseases and disorders of the oil palm in Malaysia. Incorporated Society of Planters, Kuala Lumpur. 247 pp.

Wood, B.J., 1968. Pests of oil palms in Malaysia and their control. Incorporated Society of Planters, Kuala Lumpur. 222 pp.