Weediness

Some *Acacia* species have become serious weeds. Exotic Australian *Acacia* species (e.g., *A. saligna*, *A. cyclops*, *A. melanoxylon*, and *A. dealbata*) have caused serious weediness problems in South Africa, Portugal, and Chile, whilst New World and African *Acacia* species (e.g., *A. farnesiana*, *A. nilotica*) have caused problems in Australia. The weediness of *Acacia* species means that their use in agroforestry and amenity situations must be considered very carefully.

See also: **Biodiversity**: Biodiversity in Forests. **Ecology**: Reproductive Ecology of Forest Trees; Molecular Biology of Forest Trees; Population, Conservation and Ecological Genetics. **Landscape and Planning**: Landscape Ecology, Use and Application in Forestry. **Medicinal, Food and Aromatic Plants**: Edible Products from the Forest; Forest Biodiversity Prospecting; Medicinal and Aromatic Plants: Ethnobotany and Conservation Status. **Tree Breeding, Practices**: Tropical Hardwoods Breeding and Genetic Resources. **Tropical Forests**: Monsoon Forests (Southern and Southeast Asia); Tropical Dry Forests; Tropical Moist Forests; Woody Legumes (excluding Acacias).

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Bamboos, Palms and Rattans

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Taxonomy/Genetics

Bamboos: Poaceae (Gramineae)

The family Poaceae comprises about 12 000 species in about 700 genera. Twelve subfamilies are recognized, of which the Bambusoidea is one. This subfamily includes approximately 1200 species within the tribes Bambuseae (woody bamboos) and Olyreae (olyroid or herbaceous bamboos).

Bamboos are forest grasses. The most ancient grasses were tropical forest dwellers but, as the higher grasses diversified into open areas, the true bamboos were the only major lineage of the family to adapt to the forest habitat. Bamboos are set off from other grasses by the predominance of certain 'bambusoid' structural characters, many of which are considered to be 'primitive'. The most easily recognizable vegetative features that distinguish the bamboos are the prominent development of a rhizome system, the woodiness and strong branching of the culms, the presence of petioles on the leaf blades, and the difference in form between the sheaths clothing young culm shoots and those borne on the leafy twigs. To these may be added floral characters such as well-developed lodicules, in most species three in number, and a style consisting typically of a single column, bearing one, two, or three (rarely more) stigmas.

The bambusoid grasses are naturally distributed in all continents except Europe and Antarctica. Bamboos appear more or less prominently in the natural vegetation of many parts of the tropical, subtropical, and mild temperate regions. The approximately 1100 species of woody bamboos are distributed from 46° N to 47° S latitude and from sea level to 4300 m in equatorial highlands, whereas the approximately 110 species of herbaceous bamboos occur overwhelmingly in the New World, with only two Old World representatives. The herbaceous bamboos occur principally in moist forests between 29° N and 34° S latitude and are only occasionally found above elevations of 1000 m, rarely to 2700 m. The natural distribution of bamboo in the world has been greatly modified by human intervention.

Of the 60–70 genera of woody bamboos, only *Arundinaria* occurs in both the Old World and New World. Currently, 20 genera of solely New World

woody bamboos are recognized, so there are 21 New World woody genera. Although nearly twice as many Old World genera are recognized, there are approximately 430 species of New World woody bamboos, compared with 500–600 Old World species.

In the Old World, the monsoon-belt of Southeast Asia with southern China is the main center of diversity of the bambusoid grasses. In the New World, Brazil (including the Amazon basin and the Atlantic forests) has the greatest diversity of genera and species, followed by the Andes (Venezuela to Bolivia) and Mexico and Central America.

Bamboos have a great industrial and cultural significance, particularly in East Asia, although fewer than 100 species are generally used.

Palms: Arecaceae (Palmae)

The family Arecaceae is a large group comprising approximately 2500 arboreal species to be found throughout equatorial, tropical, and subtropical areas of the world where they feature as a very peculiar element of the landscape. The main geographical areas having played the role of differentiation centers are Africa's equatorial coasts, the Indonesian region, the Sunda Isles, Oceania, Brazil's coasts, Amazonia, and the Antilles. It was during the Cretaceous period that this group had its largest diffusion and differentiation, leaving behind several fossil remains of trunks and leaves.

The family is traditionally divided into a number of subfamilies: (1) Phytelephasieae, characterized by flowers without a perianth, a large number of stamens in male flowers and female flowers bearing a multilocular ovary (4–9 locules), and infructescences (*Phytelephas*); (2) Coryphoideae, exhibiting floral characters typical of the family: free carpels, berry-like fruits, pinnate or fan-shaped leaves (*Phoenix*, *Chamaerops*, *Trachycarpus*, *Livistona*, *Sabal*, *Washingtonia*); (3) Borassoideae, characterized by fan-shaped leaves, perianth typical of the family, syncarpous ovary (*Hyphaene*, *Borassus*, *Lodoicea*); (4) Lepidocaryoideae, characterized by syncarpous ovary and fruits covered with imbricate scales (*Raphia*, *Metroxylon*, *Calamus*); (5) Ceroxyloideae, characterized by syncarpous ovary and pinnate leaves (*Arenga*, *Ceroxylon*, *Areca*, *Cocos*); (6) Nipoideae, characterized by male flowers bearing three connate stamens, and unilocular ovary (*Nipa*).

Habits of palms are quite typical, in that they are characterized by a tall, unbranched stem (up to 80 m tall in the genus *Cocos*) or, rarely, by a dichotomous branching stem (*Hyphaene*), and of the same diameter all along from base to top; at the apex they bear a rosette consisting of coriaceous, either palmate or pinnate, leaves, up to some meters long. The stem may remain quite slender, in which case it turns to a creeping habit (rattan/*Calamus*), or otherwise it may be very short in acaulescent species (*Phoenix acaulis*). Another feature peculiar to this family is that the stem reaches its ultimate growth in diameter before it starts its growth in height. Indeed, palms lack any secondary growth. Inflorescences are spadix-like, at first enveloped by a spathe or by leaf sheaths opening up at anthesis.

The fruit may be either a berry (e.g., *Phoenix*) or a drupe (e.g., *Cocos*). Only one fertilized locule carries on developing, whilst all others wither, so that the fruit contains one seed only. Pollination is mostly anemophilous; accordingly, the plant produces a large amount of pollen for this purpose.

The Arecaceae include plants of enormous economic importance for human beings, amongst them the coconut palm (*Cocos nucifera*) and the date palm (*Phoenix dactylifera*). Several species are employed in the production of vegetable fibers (*Sabal*, *Chamaerops*, *Trachycarpus*, *Borassus*). African oil palm (*Elaeis guineensis*) supports a huge industrial oil industry. Rattans are the basis of a large furniture and matting industry. Other palms with high potential as food sources include *Bactris gasipaes*, *Euterpe oleracea*, *E. precatoria*, *Jessenia bataua*, *Mauritia flexuosa*, and *Orbignya phalerata*.

Palms are also used in milder temperate-climate regions to provide trees for parks, gardens, squares, and avenues. Among the most widely used to this end are *Phoenix canariensis*, *P. dactylifera*, *Washingtonia filifera*, *W. robusta*, *Syagrus romanzoffiana*, and *Trachycarpus fortunei*.

Rattan: Calamoideae

Rattans belong to the Calamoideae, a large subfamily of palms. There are around 600 different species of rattan belonging to 13 genera and these are concentrated solely in the Old World tropics; there are no true rattans in the New World. All of the species within the Calamoideae are characterized by overlapping reflexed scales on the fruit and all of these climbing palms are spiny, a necessary preadaptation to the climbing habit. Of the 13 genera of rattan, three are endemic to Africa: *Laccosperma* (syn. *Ancistrophyllum*), *Eremospatha*, and *Oncocalamus*. Although some species within these genera are utilized locally and form the base of a thriving cottage industry, they have not, until recently, attracted much attention from commercial concerns.

The largest rattan genus is *Calamus*, with *c.* 370 species; it is represented in Africa by one very

variable species, *C. deerratus*. *Calamus* is predominantly an Asian genus and ranges from the Indian subcontinent and south China southwards and east through the Malaysian region to Fiji, Vanuatu, and tropical and subtropical parts of eastern Australia. Most of the best commercial species of rattan are members of this genus. The remaining rattan genera, *Calospatha, Ceratolobus, Daemonorops, Korthalsia, Myrialepis, Plectocomia, Plectocomiopsis, Pogonotium,* and *Retispatha*, are centered in Southeast Asia and have outliers further eastwards and northwards.

Rattans can be clustering (clump-forming) or solitary; some species, such as *Calamus subinermis*, can be both. Other species are acaulescent, having no discernible stem at all. Clustering species sometimes possess up to 50 stems of varying ages in each clump and produce suckers that continually replace those stems lost through natural senescence or through harvesting. Some clumps can be harvested many times on a defined cycle if the light conditions are conducive to the remaining suckers being able to develop and elongate.

Rattans display two main modes of flowering. In one, a period of vegetative growth is followed by the simultaneous production of flowers. Flowering and fruiting are followed by the death of the stem itself. In single-stemmed palm species, the whole organism dies after fruiting. However, in clustering species of rattan the plant coppices from the base and it is only the individual stem that dies. In the other form of flowering, flowers are produced continually and flowering and fruiting do not result in the death of the stem. All the species of *Korthalsia, Laccosperma*, *Myrialepis*, *Plectocomia*, *Plectocomiopsis*, and a few species of *Daemonorops* flower and die. Furthermore, in many of these species, stems tend to be of low quality due to the presence of a soft pith which results in poor bending properties. Such stems are also more prone to subsequent insect attack due to increased starch deposition.

Rattan fruits are often brightly colored (white, yellow, orange, or red) and attractive to birds and mammals. Birds (e.g., hornbills) and primates are the main dispersers of rattan seeds. In the Asian taxa, the seed is often covered with a fleshy seed coat. Incomplete removal of this coat often results in delayed germination, suggesting that it contains some chemical germination inhibitors. However, once this outer layer is fully removed, the germination of commercial species such as *Calamus manan* and *C. caesius* is both rapid and uniform. In contrast, in African rattan species it can be rather prolonged and it may take between 9 and 12 months before germination commences.

Ecology

Bamboo

Bamboos range in height from a few centimeters to 20 meters or more. The shorter species exist either as understory to forest stands or as edaphic or climatic climaxes (particularly in altitudinal belts on mountains). They are associates of most temperate and tropical moist or dry forest types. Bamboos are generally very tolerant of poor soils. The minimum rainfall to form closed stands seems to be around 600 mm $year^{-1}$. Bamboo species vary greatly in cold tolerance; some will not tolerate any frost but others tolerate temperatures down to $-30^{\circ}C$.

Bamboo understory species prefer light overhead shade. Bamboos may interact with fire in that they and grasses are reduced with fire exclusion. Soil impoverishment, through frequent burning, may promote development of a bamboo-dominated forest understory. Bamboo may aggressively colonize forest gaps and exclude light-demanding pioneer tree species. Under these circumstances forest composition can gradually change to be bamboo-dominant.

Pure bamboo stands occur naturally in several parts of the world. Altitudinal belts occur on East African mountains at 2400–3000 m. Bamboo forest, a type of open rain forest characterized by the dominance of arborescent bamboos of the *Guadua* genus, covers over 50% of Acre state in the southwestern Brazilian Amazon.

There is a close ecological link between bamboo forest and certain rare species – Amazonian bird species and, notably, the panda. However some bamboo stands may have a lower wildlife biodiversity than other natural forests.

Many bamboos are semelparous – they flower once after a long interval and then die. There are other plant genera with similar habits – *Agave, Ensete, Kalanchoe, Lobelia*, *Orchis*, and *Yucca*. It is not known what triggers such flowering or what benefit it is to the plant to behave in this way, although there are three main theories: bet-hedging, reproductive effort, and demographic models. Flowering seems to occur in waves, starting in one place and then migrating through nearly the entire species. The time taken to go through the wave may range from a few years to many decades. Contemporaneous flowering may occur even in ornamental bamboo plants continents away from their native range. For example, in the 1990s millions of plants of *Fargesia murieliae*, an ornamental bamboo, flowered in western Europe. As all plants were ramets of a single ortet introduced into Europe about 80 years ago, the simultaneous flowering of all these ramets constituted a single

giant compound inflorescence. Species moved within their range retain the flowering pattern of their home range. One major cohort of *Bambusa arundinacea*, widely distributed in India, has been recorded as seeding in 1868–1872, 1912–1916 and 1958–1962. On the other hand, in *Melocanna baccifera* some populations have a flowering cycle of 30–35 years, and others may have a longer (45, 60, 65 years) or shorter (7–10, 19–21, 25, 26, 27 years) cycle.

Mass flowering and dying of bamboo are important events in the ecology of their associations leading variably to such consequences as enhanced tree seeding in gaps or to explosions of rodent populations. Flowering remains largely unpredictable, unless written or oral history has accumulated, and the subsequent dying is a major although infrequent problem in the management of bamboo as a crop.

Intensification of bamboo management leads to more diseases – particularly blights and rots. Some bamboos may form a nitrogen-fixing association with azotobacteria.

Palms

Palms exist as canopy constituents of forest associations; as understory species in forests and as edaphic or climatic climax, or more properly, survivor species. Many palm species are more tolerant of harsh conditions (salt, alkali soils, harsh temperatures, drought, permanent water-logging) and are hence sometimes, along an environmental gradient, amongst the last plants to be found on such highly degraded sites. In forest associations it has been noted that palms are often found on the poorer soils.

Rattan

With habitats ranging from sea level to over 3000 m elevation, from equatorial rainforests to monsoon savannas and the foothills of the Himalayas, there is a huge range of ecological adaptation among rattans. However, rattans are predominantly plants of primary rain and monsoon forest. Rattans are distributed in tropical and subtropical areas in the Asia-Pacific region and Africa. No rattans are found growing naturally in other tropical and subtropical areas, or in the temperate regions.

Throughout their natural range, rattan species are found in a wide range of forest and soil types. Some species are common components of the forest understory, whilst some rely on good light penetration for their development; hence several species are found in gap vegetation and respond very well to canopy manipulation, particularly that caused by selective logging. Other species grow in swamps and seasonally inundated forest whilst others are more common on dry ridge tops.

Despite this wide range of ecological conditions, the majority of rattans need adequate light for their full growth and development. Although the seeds will germinate under a wide range of light conditions, the resultant seedlings will remain for long periods on the forest floor awaiting sufficient light for them to develop, such as may occur after a tree fall.

Date Palm

The date palm is a native of North Africa but has been so extensively cultivated there for thousands of years that no natural stands are thought to remain and no information on its native ecology is available.

It is cultivated and naturalized throughout the desert regions between 15° and 35° N, from the Canary Islands and Morocco in the west to India in the east. It has been recorded from all the inland and littoral parts of North Africa, from the southern parts of the Balkan peninsula and Asia minor, from Syria, Palestine, Jordan, Iraq, Arabian peninsula, Iran, and Pakistan. It is cultivated as an ornamental in southern Europe, but seldom matures fruit except in extreme southern parts of Italy and Spain. The date palm is cultivated in Arizona and California, USA, and Queensland, Australia. There is evidence of date usage 8000 years ago in India as well as its cultivation in Sumeria and ancient Egypt.

Date palm is reported to tolerate annual precipitation of 30–400 mm – a full-bearing orchard requires only 250 mm of rainfall (by rainfall or irrigation). It is grown ideally where the permanent water table is within root-reach of the soil surface. Annual temperature should be warm temperate to tropical and soil pH slightly acid to strongly alkaline. Any good soil that is not too heavy will do. Dates do well even where there is a crust of salt on the surface. Daytime temperatures of 50°C are tolerated. For proper ripening of fruit, the mean temperature between the period of flowering and ripening should be above 21°C, rising to 27°C, for at least a month. There must be no rain during flowering time. Winter temperatures below −8°C are harmful.

Oil Palm

The oil palm (*Elaeis guineensis*) is originally a native of Africa but is now widely distributed as an exotic plantation species. It is widespread in the moist tropical forests of Africa. However, even in its native range its ecology has been greatly modified by

domestication. Considerable attention is now directed to its genetic range. The Palm Oil Research Institute of Malaysia has the largest collection of *Elaeis guineensis* and *E. oleifera* germplasm in the world. Palms in over 1000 ha of germplasm gardens are being evaluated for oil yield, kernel content, height, harvest index, fatty acid composition, carotene, and vitamin E contents.

Raffia Palm

The raffia palm often occurs pure or in mixtures with mangroves and palms in wetlands and freshwater swamps in Africa. Although *Raffia regalis* is found on dry soils, and *R. farinifera* in lower mountain regions in Cameroon, the raffia palms in southern Benin are confined to freshwater swamps where the natural vegetation is forest. However, human activity has transformed this forest into a 'raphiale' where *R. hookeri* has become the main arborescent species. One sole species, *R. taedigera*, occurs in Latin America in a particular kind of swamp forest which is composed of a nearly pure stand of *R. taedigera*, growing in clumps. The leaves of *R. taedigera* grow to nearly 15 m in length and upon falling seem to eliminate the few other species of trees that might grow in water. There is conflicting evidence as to whether *R. taedigera* is actually native or introduced long ago from Africa.

Silviculture

Bamboo

Bamboos can be classified into two main types – sympodial (clumping and largely tropical) bamboos and monopodial (running and largely warm temperate bamboos). Monopodial bamboos spread by creeping rhizomes. They will naturally invade and thicken up. They can be very easily propagated by simple cuttings from the rhizomes. It is more difficult to make such cuttings from sympodial bamboo. However, techniques such as soil-layering, air-layering, and branch or culm cuttings are usually successful.

Bamboos do not suffer from a quality-degrading 'edge effect' like trees and so can be grown successfully in single clumps or in dense plantations. Bamboo shoots emerge and grow rapidly, reaching full height (which can be up to 20 m) in 40 days. In China a combination of edible shoot harvesting and respacing is used to keep a density of approximately 2500–3000 stems per hectare. Bamboo culms become mature at 4 or 5 years of age. Bamboo clumps therefore are best managed by selectively cutting the mature culms. Managed in this way, the evergreen canopy is never broken, thus maximizing soil and water conservation values. However, periodic clear-cutting has also been used successfully. Fertilizer and insecticide have been used to increase productivity. Managed conservatively, plants should last until the next flowering cycle, 50–100 years depending on species.

Bamboos have been planted in large-scale plantations; however, much of the 'bamboo seas' prevalent in China have resulted from an intensification of management in east coast monsoon forest scrub, by which farmers have gradually replaced all other species with bamboo.

Palms

In natural forests palms often occupy the poorest sites. Coconut palm lives on the edge of salty, wind-blown oceans. Date palms live in furnace-like deserts. Many palm species are extraordinarily tolerant of tough sites. Silviculture is not therefore usually problematical.

Oil palm From 1967 through to 1997, oil palm was one of the fastest-growing subsectors of the Indonesian economy, increasing 20-fold in planted area and showing a 12% average annual increases in crude palm oil production. The Malaysian oil palm industry has seen unprecedented growth in the last four decades to emerge as the leading agricultural industry in the country. From a mere 55 000 ha in 1960, the area under the crop grew more than 50-fold to 2.82 million ha in 1997. There are now, globally, 5.5 million ha of plantations. Oil palm grows well on desaturated ferrallitic soils of low fertility. Normally, however, the site is substantially, modified by cultivating, weed control, and fertilizing to achieve maximum growth. Oil palm silviculture is the subject of a highly focused and site-specific research effort. In that respect it has more in common with the major forest plantation genera such as *Acacia*, *Eucalyptus*, and *Pinus* than other palm species. Research reports indicate major efforts to control site-specific pests and diseases in monocultural plantations. Considerable effort is being applied to integrated pest management to reduce the use of pesticides. Oil palm cultivation is clearly associated with the destruction of primary or secondary rainforest and raises significant environmental issues.

Rattan Most of the rattan currently harvested comes from naturally occurring plants in tropical rainforests and is not managed silviculturally in any

way. Some village communities have evolved indigenous management techniques. Generally, however, even known good practice techniques in cutting, such that the whole plant does not die, are not applied. Rattan can be grown in plantations. As a scrambling climber it does need overhead support. As a plant it also seems to need part shade in order to develop into a vine. There are many reports of it being grown in conjunction with and over other crops, such as old rubber trees. However, the cost of plantation-grown rattan is much higher than naturally grown rattan and the quality is sometimes poorer. Consequently, there is as yet little active silvicultural management. The global management of rattan could be described as in transition from weakly regulated exploitation of a natural resource towards some kind of resource management in the future as natural resources become depleted.

Rattan is usually grown from seeds collected from wild stands. The seeds of some species are slow to germinate, needing many months in specially prepared sandy seedbeds. Nursery technique therefore needs local experimentation and adaptation to be successful.

Coconut The coconut palm grows readily from the nut. It thrives on sandy, saline soils; it requires abundant sunlight and regular rainfall over the year. Coconut can be and is grown in plantations on a range of soils well away from the sea. It is often interplanted with other crops and sometimes with N-fixing crops to reduce fertilizer need.

Date palm The date palm is propagated by seed or offshoots. Seedlings are first planted in nursery rows and later transplanted to their permanent location. Normal healthy trees may produce 10–30 or more offshoots. These will root if their bases are encased in soil. Date palms are planted between 6 and 9 m apart, with one male per 50 or more females. Date palms are sensitive to cold. In early stages, manuring is productive and palms may be intercropped with low crops like barley, pulses, and wheat. When the palms are taller, fruit trees can be intercropped. Pruning of the leaves, artificial pollination, and thinning of the fruits are also recommended. Pollination is helped by placing cut portions of the male flower spikes in the receptive female inflorescence. In Egypt, dates usually flower in February and March, ripening in August and September. Precocious trees may start fruiting at 3 years, but full crops are not usual until 5–8 years old. Old or damaged trees can be rejuvenated by air-layering the top and retransplanting it. Trees may bear for a century or more.

Utilization

Bamboo

Bamboos are used for the widest range of products imaginable. As bamboo tubes they are used as structural members for housing, for water pipes, and for musical instruments. In the split form bamboo is used to make baskets and household containers. Split and made into mats it is further fabricated into plywood. Split and carefully squared, it is made into panels and parquet flooring. As a fiber it is made into fiberboard, paper, and (experimentally) textiles. The shoots are harvested in the spring, cooked and eaten.

There is a very large internal consumption of products in each producing country. There is a substantial trade in bamboo products between countries. World trade is known to be at least US $2 billion per year. Since many products are not identified as being of bamboo in the trade statistics, total trade can only be estimated, but is conservatively thought to be over three times greater. China is the world's largest producer and accounts for approximately half of the world exports. Indonesia, the Philippines, and Vietnam are significant exporters. The EC and USA receive nearly 80% of world imports.

Palms

Palm wine, an important indigenous product, is the fermented sap from numerous species of palm trees. In Ivory Coast, it is extracted from oil palm (*Elaeis guineensis*), borassus palm (*Borassus aethiopum*), and raffia palm (*Raphia hookeri*).

Rattan

The most important product of rattan palms is cane; this is the rattan stem stripped of its leaf sheaths. This stem is solid, strong, and uniform, yet highly flexible. The canes are used either in whole or round form, especially for furniture frames, or split, peeled, or cored for matting and basketry. Other plant parts of some species of rattan – fruits, leaves, roots, and palm heart – are also utilized and contribute to the indigenous survival strategies of many forest-based communities.

However, it is for their cane that rattans are most utilized. Rattan canes are used extensively across their range by local communities and play an important role in subsistence strategies for many rural populations. The range of indigenous uses of rattan canes is vast: from bridges to baskets; from fish traps to furniture; from crossbow strings to yam ties. It is estimated that 80% of the known rattan

species is of limited commercial value due to inflexibility and being prone to breakage or possessing other poor mechanical properties, or due to biological rarity.

Coconut Palm

Coconuts are the main product of the coconut palm, and are used as whole fruits or for their parts: fibers, milk, kernel (or flesh), and husk. Coir mats are made out of coconut fiber. World production of coconuts exceeds 50 million tonnes. Indonesia, Philippines, and India between them account for over 70%.

Other parts of this plant are used too, notably its leaves to make baskets and roofing thatch. Apical buds of adult plants are an excellent palm-cabbage and an alcoholic drink known as toddy or palm wine is extracted from its sugar sap, tapped from the flowers.

Raffia

The leaves are the main products. Raffia fiber is used in floriculture and horticulture to make very tough ties, as well as a number of woven articles (mats, baskets, and hats). Raffia is tough yet very flexible and resilient leaf petioles are employed, instead of bamboo, to build houses and make various kinds of furniture. Sago, a kind of flour, is extracted from the stem pith which, before blooming, is extremely rich in starch.

Date

The fruit is the main product. Dates, due to their high sugar content, are the basic food for the people of North Africa, Arabia, and Iran. Hundreds of varieties are grown for commercial purposes. The individual varieties are recognized and prized much in the same manner as wines. Total world production exceeds 6 million tonnes. Egypt, Iran, United Arab Emirates, Saudi Arabia, Iraq, Pakistan, and Algeria (in that order) account for over 85% of world production. A considerable export trade exists to many other countries.

Palm Oil

The seeds are the main product. Prime oil, commercially known as palm kernel oil, is extracted from the seeds, which are first shelled and ground, then hot-squeezed. It is seldom extracted by means of chemical solvents. Oil content per seed ranges between 43% and 51%. This oil is very similar to coconut oil, from which it differs in its higher content of oleic acid; it is solid and buttery below 20°C, yellowish-white in color, pleasantly flavored, and it smells somewhat like coconut.

Palm kernel oil possesses a variable acidity degree, usually not exceeding 15%. It is employed for nutritious purposes as a kind of margarine or vegetable butter, or again as a partially hydrogenated oil; to this end, it is suitably refined and decolorized.

A kind of high-acidity oil, therefore of a purer quality, is extracted from the fibrous flesh of fruits after they have been hot-squeezed. This oil, whose content per fruit ranges between 40% and 70%, is mostly employed in making soaps and cosmetics or as a machinery lubricant.

During the last three decades world production of palm oil has increased from 0.9 million tonnes in 1967 to 17.4 million tonnes in 1997 from 5.5 million ha of plantations. Malaysia produces 50% of world production of oil palm fruit and Indonesia 29%.

See also: **Landscape and Planning**: Landscape Ecology, the Concepts. **Silviculture**: Managing for Tropical Non-timber Forest Products; Natural Stand Regeneration; Treatments in Tropical Silviculture.

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