A MANUAL OF CULTIVATED PALMS IN INDIA

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भारतीय वनस्पति सर्वेक्षण
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FOREWORD

The family Palmae is one of the most useful groups of flowering plants confined to the tropics. Its versatile use ranging from building materials, to paper, food, oil and medicine, leaving aside its unique horticultural value is responsible for its wide cultivation including even the arid and semi-arid zones of the tropical region. Despite its wide diversity in this sub-continent, which even provide with a remarkable landscapic effect, no comprehensive document on Palmae is available. Its general biology, anatomy, reproductive mechanism, physiological set up stress resistance, biorhythmic patterns, leaving aside the method of culturing and cultivation are all ideal ingredients of thought of researchers interested in this specialized group of plants.

The antiquity of palms too can hardly be overrated. Its existence since the dawn of civilization, reference in vedic scriptures as well as fossil records bear enough testimony of its primitiveness. Its cultivation through diverse systems, culturing *in vitro*, transplantation techniques, ecosystem preference and susceptibility to diseases are all matters of great importance to both academics, professionals and industrialists.

Undoubtedly, this treatise as the authors state is the work of five years of intensive study in this group but more important is the fact that each aspect of the book proclaims the masterly experience of Dr. Shyamal Kumar Basu and Dr. Rothin Kumar Chakraverty. It reflects their decades of experience at the Botanical Survey of India, Indian Botanic Garden and deep personal involvement of the authors in the study of this unique group of plants. I heartily congratulate them for this wonderful treatise written with meticulous care and remarkable precision. I am confident that this book would be an essential guide for any scientist engaged in the study of plants and particularly of this unique group.

March 10, 1994 (A.K. Sharma)

CENTRE OF ADVANCED STUDY
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Late Prof. T. Antony Davis, the former Head of the Natural Science Unit, Indian Statistical Institute, Calcutta who was also the Ph.D. guide of one of the authors (SKB) for his thesis on "the studies on Indian Palms" first conceived that a book containing uptodate revision of cultivated palms of India was of urgent need for the benefit of research workers, palm growers and palm lovers. Due to his untimely demise, his desire was not fulfilled.

In 1987 when Botanical Survey of India, entrusted Indian Botanic Garden to collect information for National Plant Data Base and to publish manuals of cultivated plants under the functional re-organisation programme, we thought it prudent to publish a manual of cultivated palms in India without further delay. We believe this complete manual is a befitting homage to late Prof. T. A. Davis.

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INTRODUCTION

Palms are the most fascinating group of plants that attract attention of both botanists and horticulturists all over the world. A predominantly tropical group, palms occupy a position of primacy among all other groups of plants because of their usefulness to the mankind and by their very characteristic appearance. Oil, wax, fibre, cane, dye, sago, sugar etc., are some of the main commercial products that palms yield. Palms are also a part and parcel of daily life of the rural communities in the tropics because they provide food, shelter, drinking water and other commodities for sustenance. The 'Tree of Life' in the Bible is a Date Palm *(Phoenix dactylifera)*. In Tamil poem Talavisalam written by Arunachalam, 801 uses of Palmyra Palm *(Borassus flabellifer)* have been documented. The Coconut Tree *(Cocos nucifera)* in India is regarded as a sacred tree, its green and ripe nuts are used as offerings to God. Several scriptures of Hindu and Buddhist religions were written on Tal or Talipot *(Borassus flabellifer)* palm leaves and preserved as sacred religious documents.

The beauty and elegance of palms are no less important than their traditional and commercial values. There is no substitute for the gracefulness that palms offer, palms and tropics are thus synonymous. Palms are, therefore, cultivated not only for their economic reasons but introduced in the landscape for their aesthetic value also. They are grown for beautifying interiors of houses, house gardens, parks, large estates, road sides and institutional gardens. Some species of palms are treated as potent decorative materials for creating the general atmosphere of home much pleasing and congenial. The dried fruits, bracts, prophyll and leaves of some palms are also very decorative, therefore, used for vase decoration. The hard endosperm of some palms are used as substitute of ivory and carved into beads for making attractive jewelleries.

Introduction and cultivation of exotic palms in India perhaps began at the time of first Mohammadan invasion to Sind (in undivided India) in the early eighth century when Arabian Date Palm *(Phoenix dactylifera)* was brought for cultivation in some parts of Western India (Blatter, 1926). Arab ship traders believed to have brought African Doum Palm *(Hyphaene thebaica)* to the west coast of India long before the arrival of the Europeans.

Cultivation of indigenous and exotic palms on a scientific basis was started after the establishment of East India Company's Garden in Bengal in the year 1787. Colonel Robert Kyd, the founder Superintendent of the then Company's Garden introduced some Malayan Sago Palms *(Metroxylon sagu)* which he thought would be suitable for cultivation in Bengal as substitute food plant during famine. This species did not thrive well, but several useful palms were found acceptable to the soil of lower Bengal. While appreciating multifarious uses of Indonesian Sugar Palm *(Arenga pinnata),* Sir William Roxburgh (1819), the 'Father of Indian Botany' wrote 'I cannot avoid recommending (it) to every one who possess land, particularly as low, near the coast of India to extend cultivation, thereof as possible.The palm wine itself and the sugar it yields, the black fibre for cable and cordage and the pith for sago, independently of many other uses are objects of very great importance' During the early period of the then East India Company's Garden, major attention was paid to cultivate commercially exploitable palms.Therefore, apart from Malayan Sago Palm and Indonesian Sugar Palm, African Oil Palm *(Elaeis guineensis),* South American oil yielding Babasunut Palm *(Attalea speciosa)* were also introduced. Almost all of the above mentioned exotic palms survived in the new environment but none of them proved to be commercially successful, therefore, continued to remain in cultivation only for scientific and ornamental interests.

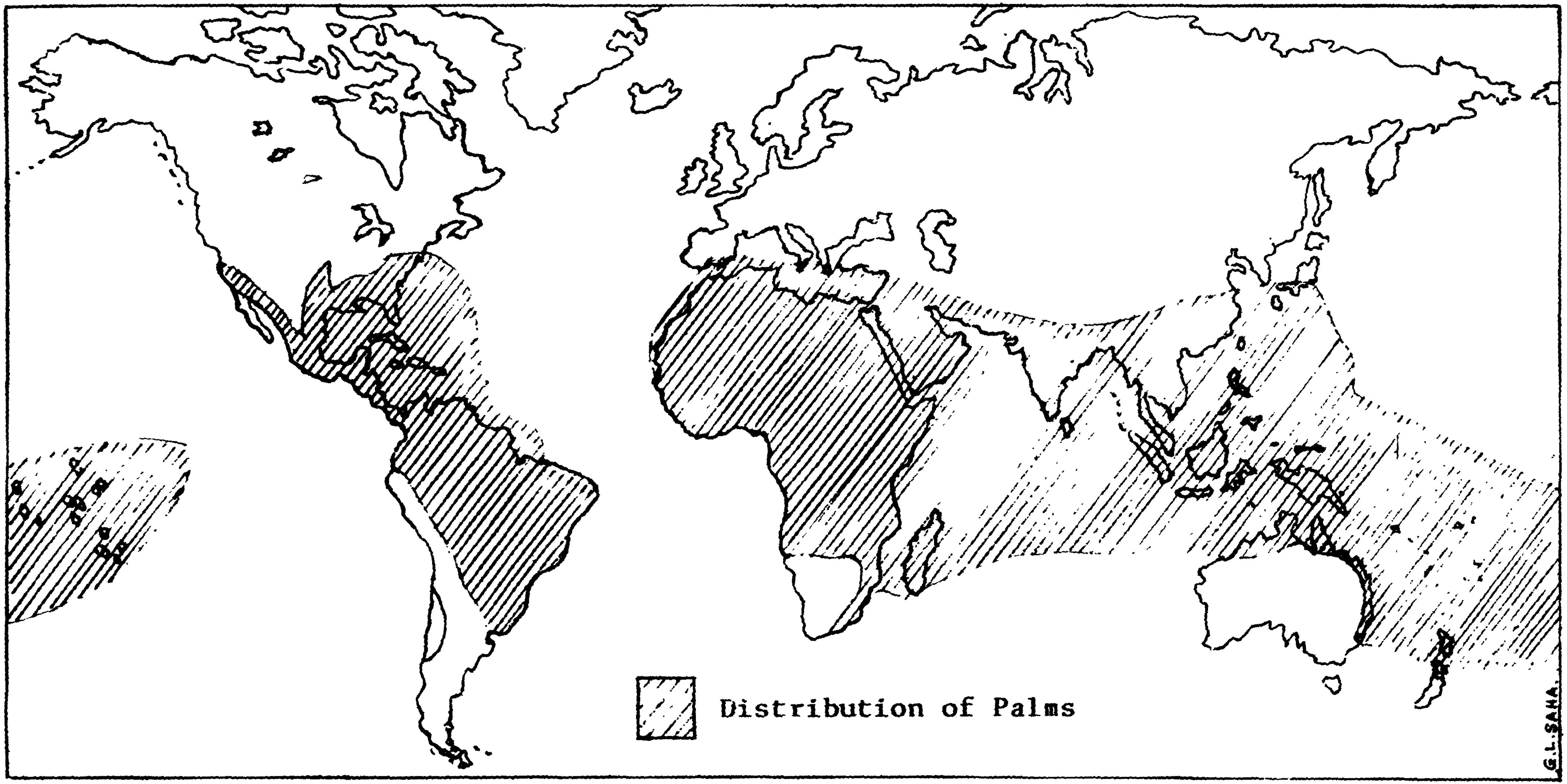
Several indigenous alongwith exotic palm species of both Old and New World tropics have since been cultivated either for botanical studies or as ornamental plants. A majority of them through the efforts of the Indian Botanic Garden, Howrah had been introduced in the country making their place in the public and private gardens. Benthall (1946) wrote 'in the former days indigenous palms were much grown in the Indian parks and gardens, but they have almost replaced by more graceful exotic kinds of which large number are planted in and around Calcutta' In the recent times there is a growing popularity for palm cultivation both for indoor and outdoor decoration and exotic palm species are being introduced at a steady stream. The credit of their introduction, however, does not always go to the Indian Botanic Garden, Howrah or other Government agencies but to the enthusiasm of numerous palm lovers in India and the endeavour of the International Palm Society who provide the palm lovers with viable seeds of exotic palm species. The newly formed Palm Society of India is also committed to popularise palm cultivation in India and to encourage young botanists in India to take up studies on the natural history of palms.

It is not exactly known how many species of palms are at present cultivated in India because quite a large number of them are the collections of the private growers, therefore, inaccessible to others or in the possession of the nurserymen who mostly do not care to enlist their palm collections with proper identity. In many important public and Government gardens in India palms are seldom labelled and listed with their correct nomenclature and thus cause inconvenience to the palm lovers.

For preparing this manual of cultivated palms in India, it was, therefore, necessary to visit all the major gardens in India and at the same time had to visit all important plant shows held during the last 5 years for recording the species of palms under cultivation in India. The main skeleton of this inventory is however deserved to be based on palm collections of the Indian Botanic Garden, Howrah, which has built up over 200 years of its existance one of the richest collection of living palms in South East Asia.

The purpose of this manual is not just to enlist by name the palms that are cultivated in India but to give an overall impression on palms to those who wish to know their biology, propagation and culture and try to identify palms in the field or in their own garden. We hope that this will be possible by the simple key and description aided with photographs and map. All examples of palms given in this book are cultivated in India. In some exceptional cases examples of some palms not yet cultivated in India have also been cited because those are typical.

A glossary of the scientific terms used in this book is given at the end with appropriate English alternatives.


Distribution of Palms
G.L.SAHA.

CHAPTER I

MORPHOLOGY OF PALMS

The vegetative structure of palms in general consists of a shoot that ends in a crown of leaves. The major reproductive process in palms is sexual through setting of seeds.

Palm Stem (Solitary)

The stem of palms is generally applied to the shoot. The most common feature of a palm is a solitary columnar stem, sometimes also termed as trunk, and crown of fan like (e.g. *Borassus flabellifer)* or feather like (e.g. *Cocos nucifera)* leaves. The single stemmed palm may be tall, dwarf, robust, slender or rarely a slender climber. The solitary stem of Doum Palm of Africa *(Hyphaene thebaica)* divides repeatedly above the soil and appears as a multiheaded tree. On rare occasion a solitary stemmed palm may manifest in their offspring a cluster forming habit by the simultaneous development of all the three active embryos in the seed. This false suckering habit has been seen in *Cocos nucifera, Borassus flabellifer* and *Rhopaloblaste augusta*. Unusual aerial branching may also occur in a single stemmed palm when injury is inflicted upon the growing terminal bud. Under abnormal condition a normally single stemmed palm may also produce several axillary shoots (bulbil shoots) in place of inflorescences. These aerial shoots may die in the course of time or grow into axillary branches as seen mostly in *Cocos nucifera, Borassus flabellifer, Phoenix sylvestris, Arenga pinnata* and *Elaeis guineensis*, which are strictly single stemmed palms. The surface of the palm stem may be smooth, rough and cracked, ringed, spiny or covered with fibrous outgrowths.

Palm Stem (Cluster Forming)

In some palms, the underground part of the stem throws out aerial shoots from the dormant axillary buds and by the repeated development of axillary shoots from below the ground the palm appears tufted with multiple stems. In some palms the underground portion of the stem throws axillary shoots which do not come out close to the main stem but grow away horizontally below the ground and appear as erect aerial shoots. By the repeated development of aerial shoots in this manner a single palm forms a huge colony of several stems. This type of colonisation is characteristic of *Acoelorraphe wrightii, Bactris major, Calamus arborescens, Rhapis excelsa, R. humilis* etc. *Chrysalidocarpus lutescens*, a normally close cluster forming palm, produces aerial shoots not from the axils of the leaves but also from the bud initiated on the abaxial side of the leaf base, in the same palm the aerial shoots may fork from the node showing distinct adnation of axillary bud with the leaf sheath.

Underground Stem

There are some palms whose stem grows underground, only their leafy crown comes above the soil thus the palms become acaulescent in appearance. The common example is *Phoenix acaulis* and *Sabal minor*. In Silver Saw Palm (*Serenoa repens)* of the coastal Florida, vegetative shoot and inflorescence both are produced from the underground prostrate stem. In the case of estuarine Nypa Palm *(Nypa fruticans)*, the underground stem grows horizontally in the mud and fork repeatedly pushing its leaves above the water level. In Salak Palm of Indonesia *(Salacca edulis)*, the underground stem also grows horizontally producing rosetted shoots above the soil.

Climbing Stem

The climbing habit in palms is a special adaptation for surviving in the tropical rain forests and seen in some groups of palms of the eastern and western tropics. All climbing palms have long slender aerial stem with long rounded internodes.They may grow upto 100 m and climb upon tallest trees of the tropical rain forests. For climbing, these palms have to depend on their special climbing organs such as flagellum, which is morphologically an axillary sterile inflorescence, and cirrus, the spiny whip-like extension of the leaf midrib. There are other climbing organs such as hooks, claws and spines below the midrib. With the exception of a few species of *Calamus* all climbing palms are cluster forming. The climbing genera of the eastern tropics are *Calamus, Daemonorops, Plectocomia, Korthalsia, Myrialepis, Ceratolobus, Cornera, Retispatha* and *Plectocomiopsis*. The last five genera are not seen in India. In the western tropics the climbing palms are *Desmoncus* and a species of *Chamaedorea*. The African climbing genera are *Ancistrophyllum, Eramospatha* and *Oncocalamus*, these are also unknown in India.

Growth of Palm Stem

The secondary meristem activity that causes thickening of the stem in dicot plants is absent in palms. In palms, all tissues are formed by the activity of the terminal bud (meristem) and this is the reason why a palm stem does not grow in length until it attains its maximum girth. Inspite of the absence of secondary growth activity in the stem, a number of palm species increase their girth by the expansion of the ground tissue together with the expansion of fibrous tissues which constitute the sheath of the conducting tissues. As this expansion of tissues are not restricted to any particular zone of the stem it is therefore termed as diffused secondary growth (Tomlinson 1961). The typical example of diffused secondary growth is seen in the Royal Palm of Cuba *(Roystonea regia)*.

Palm Leaf

Palm leaves have two basic forms : the pinnate form and the palmate form, and under these two basic forms a great diversity in shape and size of palm leaves is encountered. The longest leaf of the plant kingdom is of African Palm, *Raphia* whose one pinnate leaf is about 28 m long. The giant palmate leafblade of a Talipot Palm *(Corypha umbraculifera)* is about 4 m wide. A single leafblade of *Coco de mer (Lodoicea maldivica)* of Seychelles Islands is large enough to cover the roof of a standard size mud hut. Several species of South American *Chamaedorea* palm on the other hand have leaf as small as 60 cm in length.

The adult palm's leaves whether pinnate or palmate, consist of an axis and a blade. The axis normally has three distinct parts; the lowermost part that connects the leaf with the stem is the leaf sheath; the axial part above the leafsheath upto the point of origin of basal leaflets in pinnate leaf, and to the base of the leaf blade in palmate leaf is the petiole; the portion of the same axis beyond the petiole that holds the leaflets in pinnate leaf is the rachis (midrib). In true palmate leaf, rachis is absent or unrecognizable. In some palmate leaves petiolar axis extends into the blade, thus the flat blade curves outside; this type of curved palmate leaves are termed as costapalmate.

Leafsheath

The leafsheaths in palms have different shape, size and texture. Their structure depends on the type of mature leaf that the palm holds. Leaves that are shed immediately on drying have thin, less fibrous leafsheaths; on the other hand; leaves that remain attached to the stem even after drying for a considerable period, have thick, leathery, semiwoody leafsheaths. In some group of palms, thin, tubular leafsheaths aggregate and appear like a tube or a cylinder in continuation to the stem. This tubular or cylindrical structure appearing just below the crown is termed as crownshaft. In palms having crownshaft, the outer most leaf clears off as soon as it dries leaving behind a circular scar mark on the stem. In some groups of palms leafsheaths are slightly thicker and they do not form a perfect crownshaft but their leaves are self clearing after drying. The typical form of crownshaft is seen in the genera *Roystonea, Archontophoenix, Ptychosperma, Veitchia* etc. The palms that form no crownshaft generally have semiwoody to woody and extremely fibrous leafsheaths, as in *Cocos nucifera, Borassus flabellifer, Phoenix sylvestris, Corypha umbraculifera* etc. The hardy leafsheaths sometimes split longitudinally upto the base as a result of expansion of the stem and the splitted leafsheaths form a very regular cris-cross pattern on the stem, as seen in the genera *Sabal, Livistona, Borassus, Washingtonia, Attalea.* In the genus *Washingtonia,* not only the leafsheaths are persistent on the stem but the entire dry leaves remain on the stem for several years and form a typical "petticoat" like structure just below the crown. In some genera of palms, leafsheaths may have characteristic fibrous outgrowths from the margins and these dense fibres act as a protective covering on the stem (e.g. *Arenga pinnata, Trachycarpus fortunei,* etc.). In *Cocos nucifera,* the leafsheath fibres ramify and form large nets on both sides of the leaf base. In most genera of rattans leafsheaths are sheathing, persistent and overlapping. In the genus *Korthalsia* each leafsheath produces an upper bulbous appendage known as ocrea which sometimes acts to inhabit ants. The outer surface of the leafsheaths may have scaly cover, small hairs, felt or coated with powdery substance; may be smooth or armed with short to long spines, hooks, bristles, etc. The colour of the leafsheath in most palms is green, it may be bright red as in *Cyrtostachys* and *Latania* or yellow to yellowish green in *Areca vastiara, Chrysalidocarpus lutescens*, etc. or black in some species of *Calamus*.

Petiole

In most palmate leaved palms petiole is long. It is almost absent in some pinnate leaved palms because in these palms leaflets are formed just on the upper axial part of the leafsheath. Petiole may be halfround, round or biconvex in cross section or sometimes flattened, sunken above and rounded below. Surface and margins of the petiole may be smooth or spiny or toothed, with or without fibrous outgrowths. The outer surface of the petiole is usually smooth or covered with scales, indumentum etc., or sometimes thickly covered with spines and spicules.

Rachis

In pinnate leaves, rachis is rounded below with distinct grooves on both sides of the central ridge and the leaflets are attached in the grooves. In a true palmate leaf there is no rachis, the inner end of the leaf segments are compressed together at the uppermost point of the petiole and the entire outer folded portion spreads like a fan. In costapalmate leaves, leaf segments are also attached on the extended portion of the petiole thus the entire leafblade curves outside *(Livistona, Licuala, Sabal, Corypha*, etc).

Leafblade

Leaflets in pinnate leaves are either arranged on the rachis evenly on both sides (Paripinnate) as in coconut palm or in addition to the former pattern there occurring a terminal leaflet (imparipinnate) as in Date Palms. Some basically pinnate leaves may have entire leafblade *(Phoenicophorium)*. In some sago palms *(Caryota)*, leaves are twice pinnate and the ultimate foliar units are wedge shaped (like a fish tail).

In pinnate leaves, leaflets are either free or jointed, regular or in clusters, deflected from the rachis in one plane or in different planes. In some palms not only the lateral leaflets are jointed at irregular intervals but the terminal leaflets are also jointed thus forming two broad multinerved segments *(Areca triandra)*. The multinerved wedge shaped segments of *Normanbya normanbyi* split longitudinally and form several one nerved groups of leaflets.

The palmate leafblades may be divided into one nerved, one folded or several nerved, several folded segments. These segments divide for some distance from the margin and the undivided inner portion of the leaf blade is known as palmen.

In *Rhapis*, the multinerved segments are divided upto the base. In most fanleaved palms, the outer part of the blade is free and usually longer than the undivided middle part; the outer free parts further divide forming narrow, one nerved, entire or bilobed, drooping or stiff tips.

Folding of Palm Leaves

Leaflets in pinnate leaves or leaf segments in palmate leaves are folded at their point of attachment with the rachis or at the tips of the petioles. This folding may be as V with the main nerve below (induplicate) or folded like a reverse V (reduplicate) with the main nerve above. Induplicate folding is common in Date Palms and seen in almost all palmate leaves and partially in the leaves of *Arenga pinnata, Caryota urens,* etc.

Seedling Leaves (Eophylls)

The first foliage leaf of a palm seedling is termed as "eophyll" Its shape is varied and consistent which in turns offers a good diagnostic character. The simple form of eophyll is elongated, tapering and entire, occurs mostly in the palms of subfamily Coryphoideae and in some genera of subfamilies, Calamoideae, and Ceroxyloideae and some members of tribes Caryoteae, Iriarteae, Areceae and Cocoeae of subfamily Arecoideae. Undivided eophyll is also seen in Date Palm, Royal Palm, etc. Eophyll is bifid in most palms with reduplicately folded adult leaves. The eophyll is pinnate in most genera of rattans and in genera *Latania, Rhopaloblaste,* etc., in *Nypa fruticans,* the eophyll is imparipinnate.

Palm Inflorescence

Palm flowers are displayed on inflorescences that are considerably different from other plants. Unopened inflorescences in general are enclosed under one, two, or many fleshy bracts. The outermost of these bracts is termed as "prophyll". The fleshy prophyll and fleshy bract or bracts on the peduncle are sometimes collectively called as spathes and the inflorescence is termed as spadix. The first bract at the point of origin of flower branches in a compound inflorescence is also termed as 'prophyll'

The position of palm inflorescences may be axillary or terminal. When a palm tree after attaining maturity starts producing axillary inflorescences in ascending order as the growth advances and the position of the inflorescences remain within the crown (interfoliar) or below the crown (infrafoliar), the reproductive phenomenon is termed as 'pleonanthic' This phenomenon is common to most palms excepting a few genera and species under three subfamilies.

In two genera of Subfamily Coryphoideae and eleven genera under Subfamily Calamoideae, the shoot after a long period of vegetative growth produces a terminal compound inflorescence that composed of many axillary reproductive branch system that terminates the shoot. The entire inflorescence dies after maturation of fruits along with the death of the palm tree. This once and terminal flowering phenomenon is termed as 'monocarpism' In some cluster forming palms having this terminal flowering phenomenon, only the flowering shoots wither after maturation of the fruits but the life process of the plant continues with the development of new shoots from the underground stem, this phenomenon is termed as 'hapaxanthic' In almost all genera of the tribe Caryoteae of the Subfamily Arecoideae, the shoot after a certain period of vegetative growth produces a terminal inflorescence, followed by the development of axillary inflorescence in the descending order (basipetal) and the tree (in the single stemmed palm) or the shoot in the cluster forming palm dies after the lowermost axillary inflorescence had flowered (e.g. *Arenga pinnata, Caryota urens, C. mitis,* etc.).

Under abnormal condition a pleonanthic palm may also produce terminal inflorescence. This phenomenon has been reported in *Cocos nucifera, Chrysalidocarpus lutescens* and in a species of *Daemonorops.*

Extra Axillary Inflorescences

Normally each leaf axil of a palm bears only one inflorescence, but there are exceptions where more than one inflorescence develop from one leaf axil. The common example is *Arenga englerii.* Emergence of more than one inflorescences has also been reported in *Arenga pinnata* which normally produces one inflorescence in a leaf axil.

Structure of Palm Inflorescence

Palm inflorescences are basically axillary monopodial branch system with a strong or delicate peduncle and simple to simply branched or multiple branched flower branches.The ultimate flower bearing branches are called rachilla or rachillae. Structurally the most simple inflorescence is only an unbranched axis, as in *Calyptrocalyx spicatus.* In *Howeia belmoreana* several simple flower branches arise from a short common stalk. The highly multibranched compact inflorescences are of general occurrence in the Subfamilies Coryphoideae, Arecoideae, Nypoideae, Calamoideae and in some genera of Subfamily Ceroxyloideae. In some species of *Calamus,* inflorescences are long and flagelliform with ramified axillary fertile branches known as partial inflorescences.

Prophyll and Bracts

The term 'prophyll' was used by the well known palm taxonomist, Late H. E. Moore Jr. to denote the primary bract on the peduncle or on the lateral branches of the inflorescence with the other bracts. In general, both prophyll and bract or bracts are homologous with leaves. The shape and structure of prophyll and bract/bracts depend on the structure of inflorescences and the nature of protection the inflorescence needs before opening. The mode of emergence of flower branches from the cover of the prophyll and bract/bracts is not identical in all types of palms. In *Phoenix* the solitary prophyll is thick and persistent and envelopes the peducle and flower branches till the flowers are matured and the prophyll opens like two valves by a longitudinal split at the middle. In *Areca*, the solitary prophyll covers the entire inflorescence until it detaches from the peduncle for releasing the flower branches. In *Dictyosperma, Ptychosperma, Rhopaloblaste, Veitchia, Archoptophoenix, Carpentaria, Roystonea* and many other genera of palms of the tribe Areceae, the prophyll is large and 2-keeled (bi-carinate) and completely encloses the peduncular bract which is also large and envelopes the flower branches. At the opening, the prophyll splits from below and falls, the inner large peduncular bract expands and gets detached from the peduncle by the push of the elongating flower branches. In *Heterospathe, Chrysalidocarpus* etc., of the tribe Areceae, the prophyll is much shorter than the inner peduncular bract but fully envelopes the inflorescence at the very early stage of development. During emergence, the peduncular bract enclosing the flower branches comes out through a slit made at the tip of the prophyll. The prophyll whose base is fused with the peduncle remains attached. In *Calyptrocalyx spicatus*, both prophyll and peduncular bracts are persistent. In *Hydriastele microspadix*, the prophyll encloses the peduncular bract and both open simultaneously by a longitudinal split on the inner side for releasing the flower branches. In most genera of the tribe Cocoeae, the prophyll is small in comparison to the peduncular bract and remains hidden under the leafsheath. During emergence, the peduncular bract pierces through the prophyll and grows to a great length enclosing the flower branches and opens by a longitudinal split on the inner side. The multi-bracteate inflorescence is characteristic of Subfamilies Coryphoideae (excluding the tribe Phoeniceae), Calamoideae, Chamaedoroideae, Nypoideae and all genera of the tribe Caryoteae. In a multi-bracteate inflorescence the peduncular bract/bracts are sterile and the bracts on the rachis (main axis) and on flower branches (excepting the prophyll) are fertile because each bract holds a flower branch of the next order. In *Prichardia*, there are only sterile peduncular bracts. The genera *Arenga, Caryota* and *Wallichia* of the tribe Caryoteae have only two to many sterile peduncular bracts.

Texture of Prophyll and Bracts

The prophyll and the peduncular bract/bracts are usually thin and papery in inflorescences that emerge by the shedding of the corresponding leaves, in these inflorescences emergence is automatic therefore the prophyll and bracts do not require to be strong enough, moreover, until emergence, the unopened inflorescence during its development, gets additional protection from the leafsheath of the corresponding leaf. In interfoliar emergence, the growing inflorescence has to push out of the pressure of the leafsheaths therefore for protecting the delicate flower branches and flower buds the prophyll and covering bracts need to be thicker and stronger and more fibrous in texture.

Flower Clusters

Palm flowers are either solitary or in the form of clusters. The clusters may be of several kinds. Solitary flowers may be spirally arranged or closely crowded or irregularly disposed on the rachilla.

Cincinnus

In cincinnus flowers are sympodial in development; when a second flower develops in the axil of the floral bracteole, the bracteole below the second flower then subtending a third flower and so on. In this type of growth flower clusters of several forms are produced depending on the relative position of the bracteole and its subtending flower (Uhl and Dransfield 1987). The cincinnus type of flower cluster is characteristic in the Subfamilies Coryphoideae, Calamoideae, Ceroxyloideae and Arecoideae.

The Dyad

Dyads are characteristic of the Subfamily Calamoideae, may consists of either of two hermaphrodite flowers or two male flowers or one female and one neuter flower (sterile male flower). In the genus *Korthalsia*, the solitary bisexual flowers are reduced from dyads.

The Triad

The triad consists of two lateral male flowers and a middle female flower. It is the most common floral unit seen in palms of the Subfamily Arecoideae. By the supression of the middle female flower a triad may appear as a cluster of paired male flowers and by supression of the male flowers the cluster may represent only solitary female flower. This supression of one sex from the triad is characteristic of the genera *Areca, Caryota* and *Wallichia.*

Acervulus

Palm flowers are unisexual in the genus *Hyophorbe* and the flower clusters are formed in two lines, the proximal flower in the line is a pistillate and the distals are staminate. The bracteoles of the clusters are reduced or inconspicuous at anthesis.

Palm Flower

Palm flowers are unisexual or bisexual, sessile or pedicellate and basically trimerous with 3 sepals and 3 petals ; stamens 3-6 or many, and ovary distinctly 3 carpellate with one ovule in each carpel.

Perianth in Palm Flowers

The perianth in palm flowers is composed of similar or dissimilar sepals and petals, sometimes uniseriate with variable number of lobes. Sepals are mostly 3 in number, distinct, imbricate or connate or tubular. Petals are mostly 3 in number, imbricate or valvate or connate; mostly valvate in male flowers and bisexual flowers or rarely united with free lobes and no distinct aestivation is recognized. Petals are absent or inconspicuous in the genera *Thrinax* and *Cocoothrinax* of the tribe Corypheae.

Androecium

The androecium consists of 3 to 6 or many stamens, with distinct short or long filaments, variously connate or adnate or both with the petals. Anthers are basifixed or dorsifixed and pistillode may be present or absent in male flowers.

Gynoecium

The gynoecium is apocarpus with 1-3 carpels or syncarpus with 3 or more, rarely 10 locules or pseudomonomaerous with 2 aborted and 1-fertile locule and ovule. Carpels are smooth or hairy or with imbricated scales on the outer surfaces. Style is distinct, connate or indistinguishable. Stigmas 3, erect or recurved ; or with slit in the carpel *(Nypa)*. Ovules anatropous, hemianatropous, campylotropous or orthotropous, basally, laterally, apically attached ; 1 ovule in each locule. Staminodes may be present or absent in female flowers.

Palm Seed Germination

When palm seeds germinate and the minute embryo in the seed grows, the single cotyledon (seedling leaf) never expands and functions like a green assimilating blade, but remains partially or wholly enclosed within the seed itself and function as a hustorium to absorb nutrients of the endosperm. This special function of the cotyledon continues till the seedling is capable of uptaking nutrients from the soil by its own root system.

Dormancy in Palm Seeds

Unlike dicotyledonous seeds where dormancy is a natural process, in palms there is no true period of dormancy. The embryo which is embedded in the endosperm close to the seedcoat dries up quickly and becomes incapable of germination if favourable condition does not prevail. Hence the period of dormancy of palm seeds is the length of time required to complete drying of the embryo after maturation of the seed. The exact period of 'dormancy' is difficult to record because several internal and external factors are responsible for it. Among the internal factors, the thick endocarp cover delays drying process of the embryo. It has been found that the palms of the subtropical areas where there is marked seasonal changes, the embryo remains viable for a longer period, whereas in the humid tropics due to absence of seasonal change, the embryo looses viability quickly.

Types of Palm Seed Germination

According to the amount of extension of the cotyledonary structures following types of germination can be broadly recognized.

Remote Tubular

After sufficient growth of the cotyledon within the endosperm, the cotyledonary petiole, much more particularly the sheath, elongates carrying the embryo out of the seed into the soil. Eventually the initial leaves grow out through the long narrow oblique cleft representing the mouth of the sheath. The radicle is short lived and replaced soon by the adventitious roots. Here the ligule is absent. This typical tubular type of germination is seen in the genus *Phoenix.*

Remote Ligular

In this type of germination the cotyledonary petiole and the sheath with the ligule extend carrying the embryo out of the seed. The young seedling develops through the ligule. The remote ligular germination is common in most Coryphoid genera of palms. In *Borassus, Hyphaene* and *Lodoicea* the cotyledonary sheath may grow upto several meters into the ground before the development of shoot and roots. In *Borassus flaballifer* a succulent primary leaf is formed below the ground and is eaten as vegetable.

Adjacent Ligular

In most palm genera of the Subfamilies, Arecoideae and Calamoideae, the cotyledonary sheath does not grow longer but remaining close to the seed and the young seedling leaves develop through the adjacent ligule.

CHAPTER II

PROPAGATION OF PALMS

Palms are generally propagated by seeds, but they are also propagated by vegetative means such as by rhizomes, suckers, offsets etc. Seeds are the only means of propagation in all palms that have single stem with one terminal bud. Like many other monocot plants, palms cannot be grafted or budded or propagated by using some portion of the stem as cutting.

Propagation by Seed

Propagation by seed is the most easy, cheap and conventional method for all palms excepting those where seeds are not obtainable. The Date Palm *(Phoenix dactylifera)* although produces enormous quantity of seeds it is propagated by suckers for retaining parental characters of superior genotypes which otherwise deteriorate if propagated by seeds.

Seeds can be sown in seed beds, flats, seed pans or in pots in a soil mixture approximately 6-18 cm deep. Only the fully ripe and freshly harvested seeds should be taken for germination. In the Indian Botanic Garden, Howrah, palm seeds are germinated in the specially constructed seed beds which are about 60 cm above the ground level containing equal parts of white sand, leaf mould and garden loam. Palm seeds can also be germinated in vermiculite, a micaceous material which has the capacity to hold water and dissolved nutrients for the growing seedlings.Vermiculite also keeps the seedlings free from pests and diseases therefore it is the best medium for transporting seeds and seedlings in a disease free condition.

Palm seeds that germinate in adjacent ligular type can be sown without difficulty in any type of seed bed or seed pan depending on the number and size of the seeds to be sown. Seeds should not be sown too deep into the soil, the best result is obtained if seeds are sown about 1 cm below the surface. If the seeds are fresh no soaking with water is necessary, seeds should be cleaned, removing the fibre and the pulp. Seeds that throw longer sheaths should not be sown in beds or in deep pots because once germinated seedlings cannot be taken out for transplantation. Excepting *Latania*, all other Borassoid palms should be sown in a shallow pot keeping the seeds half buried. The giant *Lodoicea maldivica* (Giant Double Coconut) seeds cannot be sown in a standard sized seed pan. Moreover as the seed throws out several metre long sheath before producing first leaf and root, it is impossible to dig out the seedling from the nursery bed, without causing fatal injury to the young plant. Hence *Lodoicea* seed should always be sown directly at the spot where this giant palm is to be grown. For achieving success ground preparation is necessary so that the sheath can grow easily into the soil then turns up with its shoot.

The giant *Lodoicea maldivica* palm at the centre of the Large Palm House of the Indian Botanic Garden, Howrah was grown in this manner when the seed sown in 1894. For raising *Nypa fruticans* seedlings in the nursery, the best result can be obtained if the mature fruitlets are sown in mud with their stigmatic side half buried. For steady growth of the seedlings there should be water above the mud bed. It is not necessary that the water should be saline. There are some gardens in India (Theosophical Society's Garden in Adyar, Madras and Raj Bhavan Garden in Calcutta) where Nypa palms were raised and grown successfully in sweet water surroundings.

Vegetative Propagation

Some genera and species of palms have suckering or clumping habit.These palms over a period of time develop several stems (shoot) which are jointed at the base below the ground or at the ground level or the stems grow horizontally underground then come up the ground as independent shoots. In some species of *Calamus, Bactris, Rhapis,* the underground stems produce several shoots away from the main stem and form a huge colony. Therefore all palms that develop suckers and offsets and have roots below can be separated from the mother plant and each one separated can be established as a new plant.

Palm clump to be separated or splitted for taking out suckers needs careful examination for ascertaining whether the parent plant has sufficient number of suckers and healthy enough to sustain the stress of injury of splitting or severing of suckers. The suckers that have developed roots should normally be selected for separating from the parent plant. In stoloniferous palms, a portion of the underground stem along with the shoot may be separated. If the shoot has no root of its own, the practice is to cut the sucker along with the portion of the stem that joins the parent plant. This serves to cut off part of the food supply to the sucker (offset) and thus encourages it to begin new roots of its own. In some clustering palms adventitious roots develop from the nodes above the soil. By putting moist leaf mould around these roots and covering the ball of leaf mould with polythene film enhance development of more roots. The shoot alongwith the roots can be taken out and planted as a new plant. By this method it is possible to separate stems of *Hydriastele microspadix, Ptychosperma macarthurii, Rhopaloblaste singaporensis, Rhapis excelsa, R. humilis, Areca triandra, Licuala spinosa, Chrysalidocarpus lutescens,* and several cluster forming slender palms.

Bulbil Shoots

In exceptional cases, in some palms, the entire inflorescence or individual rachilla or the male and female flowers transform into vegetative shoots, popularly called as bulbil shoots. Instances of such bulbil shoot production were recorded in following palms : *Arenga pinnata, A. englerii, Areca catechu, Borassus flabellifer, Chrysalidocarpus lutescens, Cocos nucifera, Coccothrinax argentea, Elaeis* *guineensis, Phoenix sylvestris, P. rupicola* etc. These bulbil shoots may develop further as distinct shoots or wither away in the course of time. Little attention has been paid so far to utilize bulbil shoots as propagule particularly for those economically important single stemmed palms. Some attempts were made to induce bulbil formation in *Cocos nucifera*. Davis *et al.* (1981) were successful in rooting bulbil shoots in Coconut palm and to grow these rooted bulbil shoots as separate plants.

By splitting the growing point of a seedling it is also possible to induce suckers. Using this technique Davis (1968) induced sucker formation in Coconut seedling and thus effected vegetative propagation of a single stemmed palm on a small scale.

Tissue Culture in Palms

Tissue culture is invitro culture of tissue or cell taken out from the actively growing parts of plants under controlled condition in aseptic medium with the application of required nutrients. Raising of plantlets of palms by tissue culture technique is in the experimental stage. Some progress has been made towards producing callus by putting ovule sections in the nutrients medium. Reynolds *et al.* (1979) were able to produce callus from ovule sections of the palms : *Phoenix dactylifera, Howeia fosteriana* and *Chamaedorea costericana* on high auxin medium. The callus mixture when placed on auxin free medium produced numerous embroys. According to Guzmen *et al.* (1971, 1978), it was possible to grow mature embryo of Coconut palm in auxin containing medium. It was also found that high sugar concentration in the medium was effective in producing callus from the cotyledonary sheath but no true embryos have been obtained from this callus although rootlets and protocorm like bodies were produced. Scientists were able to produce callus and plantlets of some species of rattan palms and they were able to standardize the nutrients for callus formation. In Philippines, attempts were made to propagate eleven species of *Calamus* and two species of *Daemonorops* by tissue culture technique. In four species of *Calamus*, scientists in Philippines were able to produce shoots from the callus tissue in the media supported with 2-4% sucrose in the presence of 1.8 mgL benzyl adenine and 1.8 mg/L2, 4-D. Roots formed when shoots were transferred to a medium of 4% sucrose and trace of auxin in Cytokinin (Umaligarcia 1985). Tissue culture experiment in palms is still in the very early stage in India and no encouraging results have so far been reported. Tissue culture is undoubtedly the most effective method of propagation which can compete with the seed germination and has the best advantage of retaining the genetical qualities of elite palms of economic importance.