A TREATISE ON PALMYRAH

All India Co-ordinated Research Project on Palms
Tamilnadu Agricultural University
Agricultural College & Research Institute
Killikulam, Vallanadu - 628 252

Central Plantation Crops Research Institute
(Indian Council of Agricultural Research)
Kasaragod - 671 124

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by

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CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Kasaragod 670 124, Kerala
1999

Published by:

Dr KUK Nampoothri
Director
Central Plantation Crops Kasaragod Research Institute, Kasaragod

Edited by:

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Central Plantation Crops Research Institute, Kasaragod

Photo Credits:

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Correct citation:

Sankaralingam, A., Hemalatha, G. and Mohamed Ali, A.1999. ***Treatise on Palmyrah.*** (Ed). H. Hameed Khan, All India Coordinated Research Project on Palms, Agricultural College and Research Institute, T.N.A.U., Killikulam, 628 252, Tamil Nadu, India. 41 p.

1999

PREFACE

Palmyrah is included in All India Co-ordinated Research Project on Palms, besides coconut and oil palm during the eigth plan period. Tamil Nadu ranks first in India, in the population of palmyrah palms. Out of the 51.9 million trees in the State, Thoothukudi district tops with a major share of 10 million palms. Agricultural College and Research Institute, Killikulam of this district is selected as one among the two centres in India to conduct research on palmyrah. The orchard of the institute has more than 300 young and grown up palms for research.

The suggestion made in the VI Palm Scientists' Meet of Tamil Nadu Agricultural University (TNAU) during November 1997 to bring out a book on palmyrah gained momentum, and the senior author who is coordinating the activities of the scheme since its inception from April, 1994 has made an attempt to write a treaise on the palm. The publication is intended as a guide for students, research, extension personnel and farming community.

This book deals with palmyrah, beginning from its distribution in the world and India. The botany of the palm has been described with a dichotomus key to classification of Arecaceae. Though palmyrah and coconut belong to the same family, differences between them are given in detail. Scientific method of cultivation of the palm is given, emphasizing the need for crop protection measures. Field operations specific to the tree, such as tapping as well as nursery techniques have been dealt elaborately. In the topic on genetic improvement, points to ponder over crop improvement have been dealt with. Above all, when one thinks of palmyrah, one is reminded of the edible and non-edible produces that the palm yields. Since most of the edible produces are seasonal, there is a chapter devoted to the storage of such produces and the value-added products that can be prepared. The findings of the research held at TNAU so far on palmyrah are incorporated in this book.

The authors extend their sincere thanks to the honourable former Vice-chancellor, Dr A. Abdul Kareem of TNAU for granting permission to publish the book and the Vice-chancellor Dr S. Kannaiyan for his encouragement. We thank Dr S. Thamburaj, former Dean (Horticulture), Dr T.V. Karivaradaraaju, Director of Research, Dr P.C. Sundara Babu, Director, Centre for Plant Protection Studies, Dr P. Sabitha Doraisamy, Dr T. Marimuthu, Dr A. Palaniswami, Professors of Plant Pathology and Dr R.J. Rabindra, Professor Entomology for critically reviewing the manuscript and making suggestions for improvement.

I extend my sincere thanks M/s Dr V. Ponnuswami, Professor (Hort.)., Dr R. Jagannathan, Professor (Pl. Pathology), Mrs R. Amutha, Asst. Professor (Crop Physiology) and Dr P. Paramaguru, Asst. Professor (Hort.) for their whole hearted support in preparing this publication.

We are indebted to Dr H. Hameed Khan, Project Co-ordinator (Palms) and Dr. K.U.K. Nampoothiri, Director, Central Plantation Crops Research Institute, Indian Council of Agricultural Research, Kasaragod for having accepted to fund the publication and get the book printed in good quality.

I would like to specifically thank Dr P. Rethinam, Director, National Research Centre for Oil Palm, Pedavagi for his continued interest shown in the improvement of the scheme.

I am thankful to Dr I.R. Suthanthira Pandian, Professor of Horticulture and Late Dr P. Doraipandian, Professor of Horticulture, who unfolded me the mystery of palmyrah palm.

I am also grateful to my colleagues Mr M. Suresh, Dr V. Subramanian, Dr M. Dakshinamurthy for their constructive ideas during the preparation of the manuscript. I also appreciate the neat execution of typing the manuscript by Mr. S. Muthuraman.

A SANKARALINGAM

Killikulam,
August 3, 1999.

CONTENTS

INTRODUCTION

Palmyrah palm, adorns the dry landscape of the semi arid regions of Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Bihar, Karnataka and Maharashtra. India has nearly 102 million palms and half of the trees are in Tamil Nadu. Out of 51.9 million trees in Tamil Nadu, more than 50% of palms are concentrated in the southern districts of Thoothukudi, Tirunelveli, Virudhunagar and Ramnad, whileThoothukudi district alone has a major share of 10 million trees.

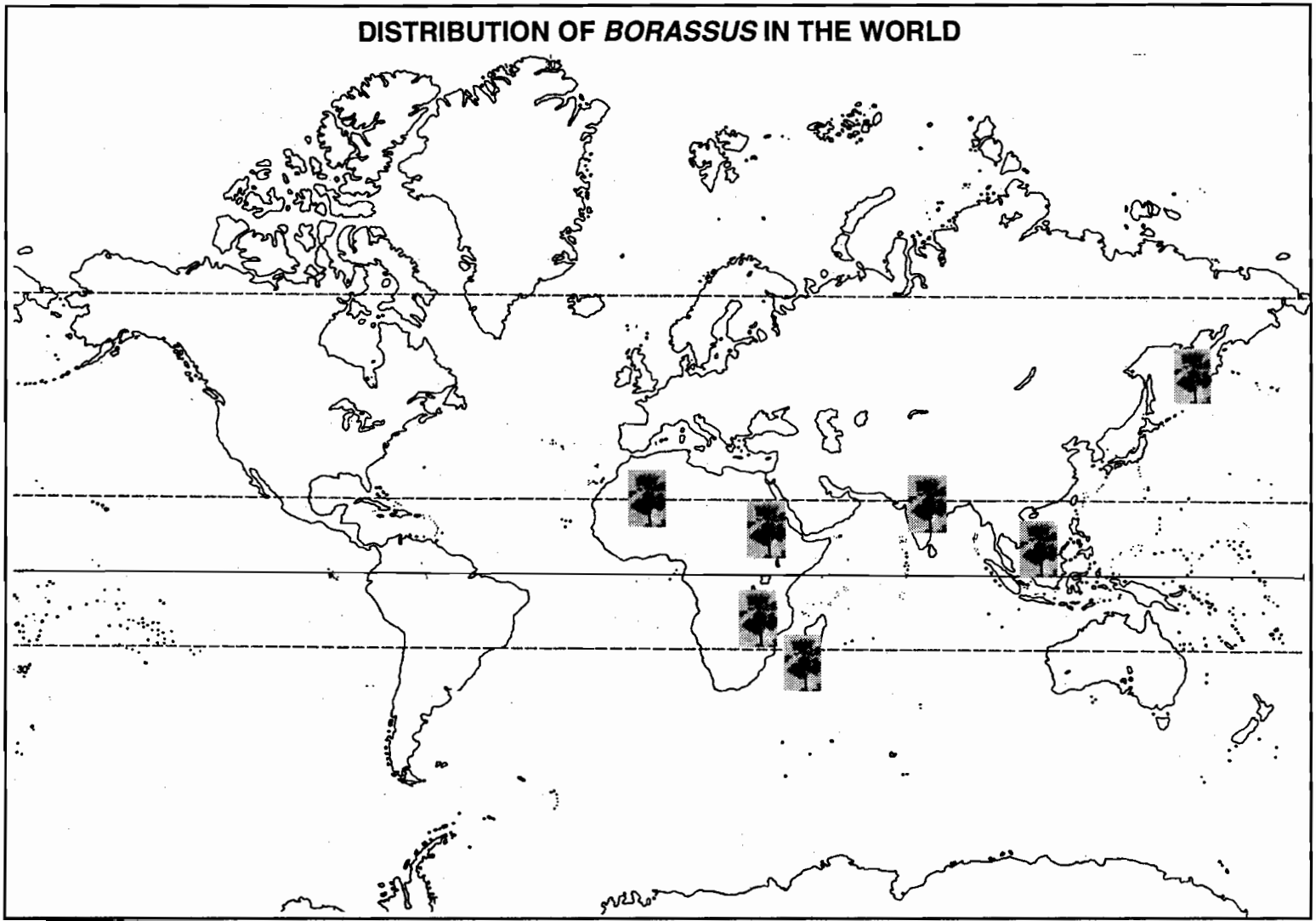
Among the four sugar yielding palms viz., *Borassus flabellifer* (palmyrah), *Phoneix sylvestris* (Date), *Caryota urens* (Sago) and *Cocos nucifera* (coconut), palmyrah palm ranks first in yielding sugar as well as other edible and non-edible produces. The sweet sap or neera collected from the inflorescence is a major source of sweetening agent and it replaces cane sugar in palmyrah growing tracts of Tamil Nadu and other states. The endosperm of immature seednuts from young fruit is a delicacy during summer like that of tender coconut. Matured fruits are roasted and the mesocarp is consumed. Many value added products can also be prepared from the fruit. From the non-edible seed nut, one can have an edible sweet spongy haustorium or apocole. Palmyrah is a fodder crop as well, since the mesocarp of tender fruit is relished by cattle.

Palmyrah is also a source of fibre. Three types of fibres from petiole, a tough fibre from leaf base and leaf are obtained. Mesocarp of the fruit also yields fibre. Several industries based on palmyrah fibre are functioning in Tamil Nadu, Andhra Pradesh and West Bengal. Varieties of fancy and utility articles are made from palm leaves, veins and roots. Mainly woman are employed in such cottage industries. Palm leaves have been used to write scripts from time immemorial. Mature leaves are cured and used for thatching while senesed leaves are utilised as fuel.

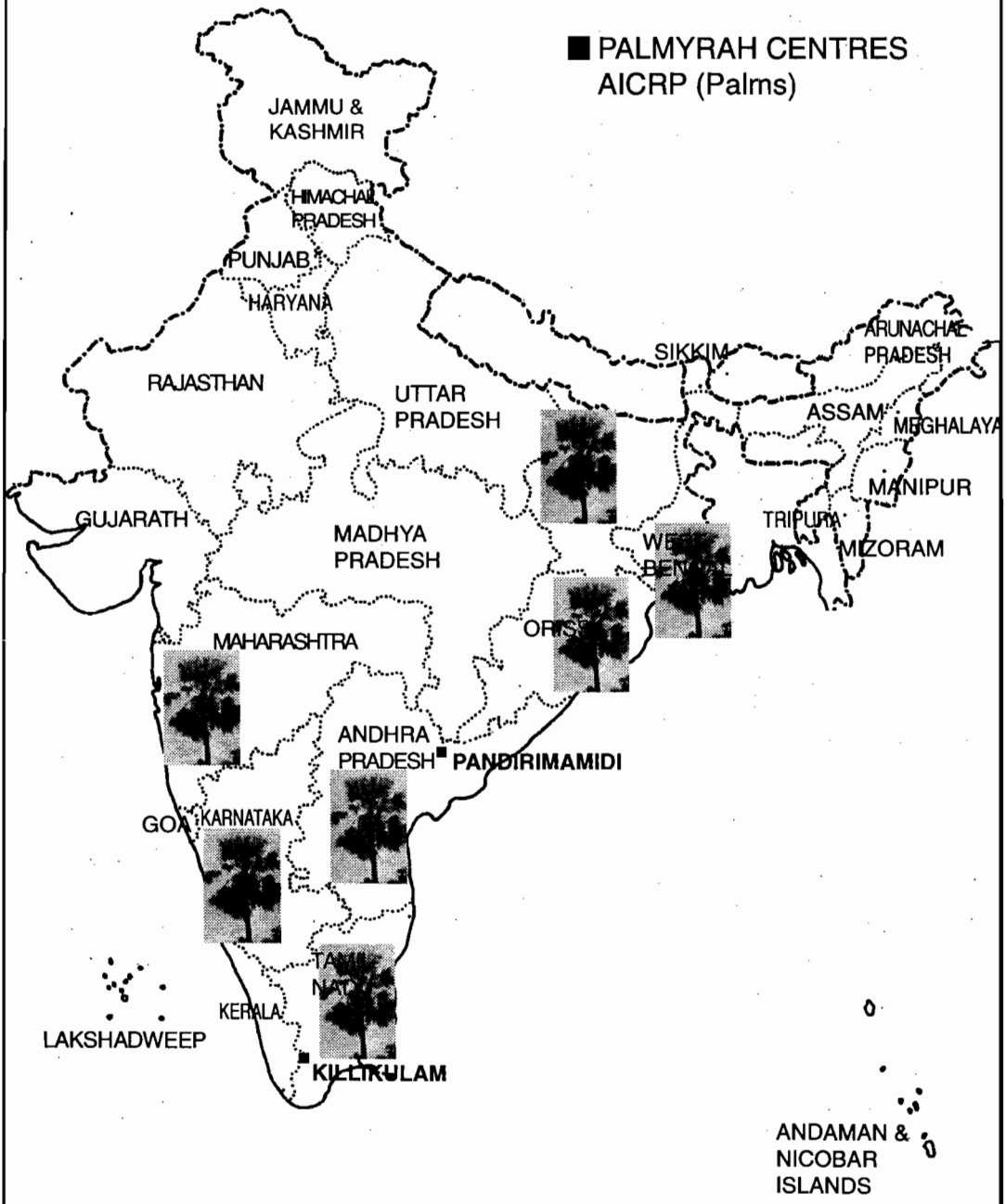
Several products of palmyrah have medicinal value. Besides sugar, neera contains minerals such as calcium, phosphorus and iron. It has vitamins like ascorbic acid, thiamine, riboflavin and niacin. Neera is a laxative promoting digestion and a diuretic serving to keep the body cool. Palm candy is a medicine to get relief from sour throat and dry cough. It is added to milk and taken as a beverage. The spadix as well as the root has medicinal value.

Palmyrah palms also serves as a wind break and arrests sand dunes in therilands. The mature outer wood of the stem is used in construction as pillars, beams and rafters.

Due to its multifarious uses, it is equated to the 'Kalpaka Vrisha' of the mythology and the Government of Tamil Nadu has honoured the palm during 1978 by declaring it as a State tree.


DISTRIBUTION OF *BORASSUS* IN THE WORLD

DISTRIBUTION OF *BORASSUS FLABELLIFER* IN INDIA



Borassus and other Genera in Family '*Arecaceae*'

A Dichotomous Key for Classification

1. Leaves simple, palmate

    2. Infl. terminal > 6 m long, monoecious, carpel 1, free, seed without a stony coat. Petioles massively spinous — *Corypha*

    2. Infl. interfoliar, < 1 m long, dioecious, carpels fused, seeds 3 each with a thick stony wall. Petioles shortly spinous — *Borassus*

1. Leaves compound, pinnate

    3. Stragglers, spadices as long as leaves with an apical flagellum, unisexual — *Calamus*

    3. Shrubs or trees, spadices shorter than leaves without apical flagellum

        4. Leaves 2 pinnate, leaflets obliquely cuneate, apical margin caudate, monoecious — *Caryota*

        4. Leaves 1 pinnate, leaflets linear, oblong, margin entire

            5. Lowest leaflets modified into spines, dioecious, ovary of 3 free carpels, wild — *Phoneix*

            5. Lowest leaflets non spinous, monoecious, ovary of 1 carpel, cultivated

                6. Drupes 3.5 cm long, leaflets apically praemorse, leaf sheath tubular, stem < 15 cm in dia — *Areca*

                6. Drupes 10-30 cm long, leaflets apically acuminate, leaf sheath 0, stem > 40 cm across — *Cocos*

(after K.M. Mathew, 1991)

BOTANY OF PALMYRAH

Name	:	*Borassus flabellifer* L.
Family	:	Arecaceae
Origin	:	Africa
Other species	:	*B. althiopum* Mart., *B. sundaica* Becc.
Distribution	:	Mauritiana, Senegal, Mali, Gambia, Guinea-Bissau, Guinea, Ivory Coast, Upper Volta, Nigeria, Gaban , Congo, Sudan, Tanzania, Madagascar, Saudi Arabia, Iraq, Iran, Pakistan, Bangladesh, Sri Lanka, Myanmar, Thailand, Kampuchea, Malaysia, Indonesia.

Ploidy

X = 8 or 9, n = 18, Allotetraploid, Dioecious, Sex ratio 1:1. The male tree has a heteromorphic XY pair of chromosomes while the female has an XX pair.

Root

Root system is adventitious in nature. Roots originate from the internodes at the base of the stem. New roots are formed and added continuously at the higher levels of the stem as it enlarges. The main roots are string like giving rise to many lateral branches, which branch off further. Mature roots have a sclerotic exodermis.

Stem

Stem is tall, unbranched with rare exceptions and grows to a height of 20 - 30 m. Stem diameter range from 60 - 90 cm. Cortex in stem is narrow bearing vascular bundles that have massive phloem sheaths. Paranchyma cells close to the vascular bundles are isodiametric in shape and found in groups. Vascular bundles are 1200 - 3300 μ in length and 150 - 250 μ in width.

Leaf

Stem is topped by a crown of 20 - 30 large leaves. Each leaf has a stout long petiole of 0.9 to 1.5 m long and a rachis with lamina. The petiole base is broad having a vertical split and it is persistent. It clasps the stem almost half the circumference and is surrounded by a fibrous net work of stipules. Leaf petiole is adaxially grooved with sclerotic serrated margin. Leaf lamina is palmate, large, 1.0 to 1.5 m long with 60 - 80 compound segments. Leaf lamina is plicate with ribs, extending along adaxial folds. Leaf segments are induplicate. Foliar spirals are either left or right handed with alternate phyllotaxy, that helps efficient utilization of sun light. The stem of the young palm is ensheathed with petiole base and dried leaves while that of adult palms is marked with scars of petiole base.

Inflorescence

Sex in palms can be differentiated only during flowering. Flowering is seasonal. The inflorescence is interfoliar and a branched spadix, sheathed by many imbricated, fibrous,

coriaceous spathes. The outer most spathe is the smallest one while the inner most one is the longest. A palm produces 5-8 spadices annually.

Male spadix

The male spadix has 5 - 10 branches and each branch is ensheathed by a spathe. Each branch has 2-3 branchlets or spikes. Each spike is stout, cylindrical, 30-40 cm long and 2.5-4.0 cm wide. The width of the spike decreases gradually from base to apex. The spikes are imbricated by numerous bracts. the bracts are wedge shaped, cuneate, retuse and adhere by their lateral margins to the keel or back next one above, to form a cavity enclosing small scorpoid spikelets.

The number of spikelets in each spike range from 800-1000 and each spikelet has 15-20 sessile, little florets. Each flower in the spikelet is substended by small, semitransparent cuneate bracteoles. The flowers in spikelets are arranged in two vertically opposite rows, serrated into each other, each spikelet forming an arch. The spikelets are arranged in parallel and nearly straight rows running clockwise or counter clockwise, around the spike.

In total, a single spadix may contain 2,00,000 to 2,50,000 florets. Flowers are sessile, sepals 3, imbricate, cuneate with truncate tips. Petals 3, short, ovate and imbricate. Stamens 6, filaments connate into a stalk with corolla. Anthers large, sessile, oblong, bilocular and split longitudinally. Filament dark and dorsifixed.

It takes 16-25 days for the flowers to open after the opening of spathes. Flowers open from the lower half of the spike and extend to both ends. Rarely more than one flower opens at a time. Pollen shedding is simultaneous with flower opening and pollen grains are ellipsoidal.

Female Spadix

The female spadix has only 2-4 branches or spikes, sheathed by spathes. The upper half of the spike is imbricated by bracts while the lower end is a smooth peduncle. A barren bract ensheaths the spike, from where the flowers rise and the terminal of the spike estending to 5-8 cm beyond the flowers is also ensheathed by barren bracts.

The number of female flowers in a spadix range from 30-75. The female flowers are large, globose, perianth is 6 lobed, fleshy, imbricate, reniform and accrescent. Staminodes 6, ovary globose, 3-4 celled, pistils 3-4, syncarpous, stigma 3, sessile and recurved. Ovules are basal and erect.

Pollination

Though flowers bloom throughout the day, most of them open between 8 and 11 a.m. Pollination is through insects (bees, wasps, beetles) and wind. It takes 120 - 130 days for the fertilized female flowers to mature into ripe fruits.

Fruit

The fruit is a fleshy drupe and weighs 1 - 3 kg. It is nearly spherical with flat bottom. At the stalk end, six reniform perianth lobes are arranged in two whorls of three each. The epicarp is thin, fibrous and brittle. It is creamy when young and turns black or pinkish yellow on maturity. The mesocarp is fleshy and fibrous, when fully ripe.

Though the fruit develops from three fused carpels, the number of pyrenes within mesocarp varies from 1 - 3. The endocarp is hard, and it covers each seed, which has a brown testa. The endosperm is gelatinous when the seed is young, filling the entire cavity after 60 - 70 days of fertilization. As the fruit matures, the endosperm hardens, forming a cavity at its centre. The embryo is positioned below the germpore and embeded within the endosperm. The germpore is situated at the stigmatic end of the fruit.

Germination

Germination of palmyrah and date seednuts are quite distinct from the other related genera of the family *Arecaceae*. Both show extension of cotyledonary sheath.

Apocolon

Seednuts of palmyrah germinate within 15 - 20 days of sowing. During germination of the nut, the single cotyledon enlarges and emerges out as germtube breaking the endocarp. The germtube, elongates as a pale yellow sheath enclosing the embryo and carries it down. This hypocotyl is referred as 'apocolon', which is a storage organ of the first rudimentary leaf which gets initiated at the centre of the apocole. The apocolon though referred as 'tuber' is neither a modified stem nor a root. It is a modified hypocotyl enclosing the coleoptile and coleorhiza. During early stages of apocolon formation, the haustorium which is formed in the centre of the seednut stores the hydrolysed sugars of the endosperm, and the haustorium is spongy.

During apocolon maturity as days advance, the stored metabolites and nutrients from the endosperm of the seednut get mobilized leading to an increase in the weight of the apocolon. This results in a decrease in weight of the pyrene, leading to an empty endocarp, which gets detatched from the apocolon finally. As the apocolon matures, the sheath which initially carried the apocolon down, gradually looses its weight, becomes thin and leathery. When the apocolon reaches optimum maturity, the radicle comes out of the apocolon base leading to the formation of roots. Finally the plumule comes out of the apocolon and grows from the soil forming the spindle shaped first leaf. It takes 150 - 160 days for the first leaf of the seedling to come out of the soil.

PALMYRAH AND COCONUT - A COMPARISON

Borassus flabellifer L.	*Cocos nucifera* L.
Dioecious	Monoecious
Leaf	
Palmate	Pinnate, pinnatisect
Leaf segments induplicate (V)	Leaf segments reduplicate (Λ)
Leaf base broad, vertically split	Leaf base not split
Petiole stout, short, spinous	Petiole slender, long, nonspinous
Foliar spirals 3	Foliar spirals 5
Infloresence	
Flowering seasonal (2-4 months)	Flowers throughout the year
Spadix interfoliar, male spadix large, long more branched than female	Spadix interfoliar short, less branched
Male flowers small, clustered, sessile with 6 stamens, sepals 3, connate, truncate, petals 3, ovate, imbricate.	Male flowers bigger, often paired, shortly pedicillate with six stamens, perianth 6, thin
2,00,000-2,50,000 flowers in male spadix	8,000-10,000 male flowers in spadix
Female flowers globose, bigger with 6 accrescent perianths	Female flowers globose smaller with 6 accrescent perianths
Pollination-Allogamous	Pollination-Allogamous, autogamous
Pollination to fruit maturity-4 months	Pollination to fruit maturity-11,12 months
Fruit	
A fleshy spherical drupe with thin brittle, black or pinkish yellow epicarp	An ovoid drupe with thin green epicarp
Mesocarp: fleshy, fibrous, edible	Mesocarp: fibrous
Drupe with 1-3 hard pyrenes	Drupe with one hard pyrene
Germination and growth	
Germpore at stigmatic end of fruit	Germpore at stalk end of fruit
Apocolon carries embryo into soil, radicle emerges out of its base leading to root, plumule emerges from apolocolon centre, grows out of soil leading to tuberous leaf	Plumule emerges out of germpore, comes up through soil leading to shoot, while radicle grows down leading to root
A slow grower, takes 12-15 years for the tree to come for bearing	Relatively a fast grower, can start yielding from 4-5 years
Can grow in zones with annual rainfall of 750 mm	Requires well spread annual rainfall of 2000 mm
Chlorophyll Stability Index=91.85%	85.87%
Relative water content=92.4%	86.60%
Uses	
Tops among four sugar yielding palms (palmyrah, date, sago palm, coconut)	Not a major sugar yielder, an oil yielding crop.
Mature endosperm hard to separate from endocarp (shell)	Mature endosperm separable from endocarp and oil yielding
Endosperm in tender fruit is a delicacy	Endosperm in tender fruit is a delicacy
Mesocarp of ripe fruit, thavan from seednut, apocole are edible produces	Endosperm of ripe fruit is an edible produce
Petiole, leaf base are the major sources of fibre	Mesocarp of fruit is the major source of fibre

Advantages of cultivating palmyrah in place of coconut:

* Palmyrah is drought tolerant since its Chlorophyll Stability Index and Relative Water Content are higher when compared to coconut.

* Palmyrah requires less rainfall and care. Hence it can be planted in theri lands, sandy plains, field bunds and on sides of rail tracks.

* The palm can be used as wind break to prevent soil erosion as well as the formation of sand dunes.

* The palm also serves as a fire breaker.

* Though palmyrah is a slow grower, if protected from stray cattle by live fencing, the palm will come to bearing quickly.

* Palmyrah is referred as tree of life with nearly 800 uses including food, beverage, fibre, fodder, medicinal and timber. The tree serves as a source of raw material for several cottage industries.

CULTIVATION PRACTICES

Soil

Palm can be grown in wide range of soils including theri and waste lands. However, on sandy soil, red soil, black soil and river alluvium the palms thrive well.

Climate

Adaptable to semi-arid regions receiving an annual rainfall of less than 750 mm. Altitude - Sea level to 800 m.

Planting season

During north-east monsoon (October - November)

Seednuts and sowing

Ripe fruits are collected from the elite trees and heaped under shade for four weeks. Separated seednuts are loosened from the fruits and are soaked in carbendazim 0.1% for 24 hours to reduce tuber rot incidence and enhance germination.

Spacing

3 m x 3 m

Population

1110/ha (450/acre). Dioecious in nature and the sex ratio of male to female is 1:1.

Planting

Pit size is 30 cm x 30 cm x 60 cm. The pit is half filled with a mixture of farmyard manure (10 kg) and top soil. The nut is positioned with its germpore (narrow conical end) facing down or sidewise at 5 cm depth and 100 g of malathion 4% dust is sprinkled around it and the nut is covered with soil.

Watering

Planting coincides with monsoon. If rain fails, pot watering immediately after planting and at alternate days up to a month is required. Later watering can be done once in a week during non-rainy periods for a year. If rainfall is scarce, pitcher irrigation can be provided twice a month during tapping season to increase neera and fruit yield.

Shade

In *theri* lands, young seedlings require shade to protect them against sun and desicating wind, using one or two dried palm leaves.

Fencing

Fencing is essential to keep away the stray cattle from pulling out the tuber and feeding on young foliage. If not, it will affect the growth and unduly extend the tree bearing period even up to 20-25 years.

Manuring

For manuring, farmers generally adopt sheep penning. However application of FYM at 10 kg/pit before planting the nut and subsequently increasing the application of FYM @ 10 kg for every 2 years from 10 kg in the first year till a dose of 60 kg is reached on the 11th year is desired. The same quantity is continued thereafter.

After cultivation

Gap filling is required. Ploughing the interspace before monsoon and rectification of basin of 45 cm around young seedlings is essential. For grown up palms the basin has to be widened to 2 m around the base. Young leaves should not be removed from juvenile palms. One or two leaves can be removed later, when the palms reach a height of 2 m. Adult trees can be defoliated up to 50% leaving 16 - 22 leaves at the crown. Removing all the leaves leaving the bud and crown is totally harmful to the palm. Foliage and butts (leaf base) should not be removed during summer. Butts and old senesed leaves are to be removed and the tree cleaned once a year before monsoon or tapping. Care should be taken not to injure the stem while cleaning.

Intercropping

Groundnut, gingelly, cowpea and greengram can be raised as intercrops during rainy season. Moringa as a border crop fairs well. Fruit trees like ber, custard apple, West Indian cherry can also be planted as mixed crops.

Yield

In a tapping duration of four months, a palm can yield 100 - 200 litres of neera commencing from 12 to 15 years. Fruit yield from female tree range from 70 to 200.

CROP PROTECTION

INSECTS ON PALMYRAH PALM

Rhinoceros beetle *(Oryctes rhinoceros)*

Damage

The adult beetles inflict damage to the crown, buds, young leaves and petiole. Spathes and spadices also get attacked.

Control

The crown and the space between leaf axils are to be filled with a mixture of 250 g of malathion 4% dust and sand in equal proportion. The crown is examined and the adult beetles are hooked out and killed. In young palm, three naphthalene balls are kept at the leaf axils once in 45 days. Since the grubs proliferate in manure pits, malathion 4% dust can be applied and mixed with manure. Release of baculovirus inoculated adult beetle will reduce the leaf and crown damage. Soaking castor cake in water and keeping it in pots in and around the garden will attract adult beetles. Longitudinally split palm petioles are soaked in toddy and kept in the garden to bait the beetles.

Red Palm Weevil *(Rhyncophorus ferrugineus)*

Damage

Here the grubs cause damage where they feed on the soft pith within stem and crown, leading to drying. Patches of viscous fluid may ooze out of the bore holes on the stem.

Control

Care should be taken not to damage the stem while removing the butts or leaves. Removal and burning of wilted and damaged palms is necessary, since it may serve as a breeding ground for the weevils. Treating wounds if any, on the stem can be done with a mixture of malathion 50% W.P. and tar. Root feeding with monocrotophos 10 ml in 30 ml of water during off season is required. Root feeding should be stopped 45 days prior to tapping and should not be done during the tapping period of April to July to prevent any harmful effect on users of neera.

Black headed caterpillar *(Opisina arenosella)*

Damage

Young palms are more susceptible to infestation. Larvae scrap chlorophyll and feed on them leaving only the rachis. They form galleries on lower side of the leaves.

Control

Removal and destruction of severely damaged leaves has to be done. Periodical release of larval (Brachondis, Bethylids) and pupal (Eulophids) parasites and predators is required. The larval parasites Brachonids and Bethylids are released @ 5/tree, while the pupal parasite Eulophid is released @ 10/tree. Depending on the infestation level, these

Pest and Diseases of Palmyrah Palm

Pests

Oryctes rhinoceros

Opisina arenosella

Diseases

Pestalotia palmarum

Rhizoctonia solani

parasites are to be released two to three times at 20 day intervals. On young palms foliar application of malathion or monocrotophos @ 1 ml/litre of water can be resorted to.

DISEASES ON PALMYRAH PALM

Tuber rot in nursery *(Rhizoctonia solani)*

Symptoms

Infestation leads to blackening of the golden colored skin of the tuber, with liquid oozing out. Such tubers break-off while scooping. White to grey mycelial growth of the fungus can be seen on infected tubers.

Control

When tubers are raised for edibe purpose, the nursery has to be prepared in raised beds of size 1 m x 1 m x 0.5 m. A mixture of red earth and sand (3:1) is best suited for the nursery preparation. Seednuts after loosening from fruits and fibres are soaked in carbendazim 0.1% for 24 hours prior to sowing.

Foliar diseases

Leaf spot *(Stigmina palmivora)*

Symptoms

Young seedlings and juvenile palms are more susceptible to this disease. Small reddish brown necrotic spots of less than 0.5 cm in size appear all over the leaves. Several spots coalesce resulting in brown patches leading to drying of foliage.

Leaf blight *(Pestalotia palmarum)*

Symptoms

Palms at all ages are susceptible. Spots are relatively bigger having 1.0 to 1.5 cm length and 0.5 cm in width. Spots generally appear on older leaves. They are linear in shape with grey margins and brown centres. Many spots coalesce and lead to blight.

Control

Both leaf spot and leaf blight can be managed by spraying 0.2% copper oxychloride.

Bud rot *(Phytophthora palmivora)*

Symptoms

Spear leaves become yellow and turn brown later. Infected spear bends at its base and hangs. Due to rotting of infected tissues, the spear comes off easily when pulled. Palms emit offensive odur. If unchecked, rotting will proceed to meristem leading to wilting. The disease is noticed during monsoon season and it is favoured by the damage caused by rhinoceros beetle.

Control

Removal of infected tissues and cleaning up the crown has to be carried out. Drenching the crown with 1% Bordeaux mixture or 0.2% copper oxychloride can be adopted. Palms can be saved if only the infection is detected at an early stage.

OTHER INFORMATION

TAPPING

Palmyrah palm comes to flowering at 10 - 12 years under ideal growth conditions. The palm put forth 5 - 8 spadices every year. Tapping for neera is done in both male and female trees. Since flowering in palmyrah is seasonal, tapping is normally done for a period of 90 - 130 days from April to July. Before tapping, old senescent leaves, leaf bases and stipules are removed. Defoliation up to 50% of the total fronds is found to enhance the neera yield.

Tapping refers to stimulating the palm and inducing the inflorescence to exude juice and collecting the sap. Tapping constitutes crushing and rupturing the tender tissues of the inflorescence by gently hammering and massaging the spadix. The process is repeated for six days. The spadix becomes pliable and it is bent and the apical tissue is pared off with a special knife. Later, a mud pot coated with quick lime is tied for collecting the sap. Slicing is done twice a day, once in the morning and afternoon. This allows the sap to be directed towards the wounded region through the vascular bundles of the peduncle. Slicing is continued till the spadix becomes a stump.

Though the yield of neera is influenced by genetic factors, the following conditions also determine the neera yield of a palm.

1. Type and fertility of the soil and irrigation facilities.
2. Management practices viz., sheep penning, manuring, ploughing etc.
3. Within a tree, yield may vary between spadices.
4. Rains during tapping drastically reduce the yield and quality.
5. Wind velocity and dryness also affect neera yield.
6. Influenced by the skill of the climber who taps neera.

Neera yield from a tree will be initially less during April and it increases during May, June and declines in July. During the tapping season the yield of neera from a palm varies from 100 - 200 litres. A palm yields a minimum of one litre of neera to a maximum of 12 litres per day.

NURSERY TECHNIQUES

Containerised seedlings

Seednuts of palmyrah are generally directly sown in the field during monsoon. Nut germination normally range from 60 to 65%, resulting in gaps in the field. Since fruiting of the palm is seasonal and the palm is a slow grower and gap filling will lead to variations among trees in a plantation. Besides, the mature apocolon breaks off easily at its base when pulled out, if the soil is hard leading to seedling mortality. To avoid these constraints containerised seedlings of optimum age can be used for gap filling. The production involves two stages.

Stage 1

Masonry beds are constructed over ground surface using single bricks as retention walls, which are plastered with red earth. The beds can be 0.6 m in height, 1 m in width with convenient length. The beds are filled with sand to a height of 0.5 m. The seed nuts are treated with 0.1% carbendazim for 24 hours and are closely placed on the bed in rows with a gap of 10 cm in between the rows and covered with sand to a height of 5 cm. These beds are to be watered twice a week. Such beds can be covered with polythene sheets or mulched with cut weeds. Apocolon raised in masonry beds as mentioned above are removed, placed in polythene bags and allowed to root in a conducive atmosphere as given in stage 2.

Stage 2

After 90 days, the masonry bed is dismantled. Root of the apocole is pared and the base of the apocolon is kept in a composite solution of diammonium phosphate 2%, muriate of potash 2% and 25 ppm NAA for three hours. Later the apocolon base is dipped in carbendazim 0.1% or copper oxychloride 0.25% and planted 3 cm deep in polythene bags (8 x 12 cm) filled with sand. The containerised seedlings are arranged in pits of 1 m wide, 1 m deep having convenient length. The pits are watered 3 - 4 times a day and covered with polythene sheets to provide a conducive microclimate for root development. In 50 - 60 days the seedlings will have profuse rooting. Later it is enough if seedlings are watered twice a day. Now the seedlings can be removed from the pit and kept under shade for two weeks before they are finally moved to direct sunlight for hardening.

The seedlings have to be planted in the main field, deep to the point of tuberisation in pits filled with equal proportion of soil and sand for better performance. Seedlings may be soaked in water or 50 ppm NAA for better rooting.

These containerised seedlings can be transplanted in the field during monsoon without any mortality. In establishing new plantations, the use of such seedlings will lead to trees of uniform vigour in due course.

TUBER PRODUCTION

A mixture of red earth and sand at the ratio of 3:1 is best suited to get robust tubers for edible purpose. Seednuts treated with the fungicide are laid closely, positioning the germpore facing down or sidewise on mounds (1x1x0.5m^3) and covered with the mixture up to 5 cm. Palmyrah seednuts do not require any over head shade in the nursery to protect the apocolon from the impact of heat from the sun. The beds have to be watered once a week to get maximum tuber yield. Though seednuts germinate in 15-20 days the optimum time for harvest is 135 days after sowing (Table 1).

Table 1. Development of tuber in palmyrah

Parameters	Harvest after days			
	90	105	120	135
Nut weight (g)	213.0	196.0	168.5	140.0
Thavan weight (g)	28.0	30.0	24.0	18.5
Tuber weight (g)	30.8	41.5	53.7	79.0
Sheath weiht (g)	50.5	43.5	30.0	25.5
Total weight of tuber with sheath	81.3	85.0	83.7	104.5

GENETIC IMPROVEMENT

In *Borassus flabellifer*, selection for elite genotypes is mainly based on fruit and neera yield. As far as fruit yield is concerned, a female tree normally produces 5-6 spadices having nearly 50-60 fruits. However, there are trees that are capable of yielding 200-300 fruits in a season. The variety SVPR 1, released from the erstwhile Palmyrah Research Station, Srivilliputhur, Tamil Nadu, has yielded 140 - 150 fruits in a year. Trees with such traits are to be selected while aiming at high yields for tender, mature fruits and apocolon.

Another aspect for selection, is the yield of neera. Neera yield normally ranges from 100 - 200 litres in a season and trees capable of yielding more than 150 litres can be considered as high yielders. It is stated that female trees are better yielders of neera than males. The variety, SVPR 1, a female tree has yielded 298 litres of neera in a tapping duration of 97 days. A shorter tapping duration of 60-70 days may reduce the dredgery of the climber. However, certain genotypes are capable of giving economic yields even beyond 90 days.

Besides neera and fruit yield, components of drupe also exhibit a wide range of variation which can be exploited during selection.

The genotypic and phenotyoic variances are found to be the highest for the variable flesh weight with epicarp followed by fruit weight , weight per nut and nut weight per fruit, as indicated by high genotypic and phenotypic coefficients of variation (Table 2). Besides these, high genetic advance is also noticed for flesh weight with epicarp followed by weight per nut, nut weight per fruit and fruit weight.

The effectiveness of selection is based on heritability which relies on genotypic performance. High heritability combined with high genetic advance also indicate the role of additive gene effects. Hence, while selecting high yielders for tender fruits, drupe and apocolon, genotypes could be identified based on flesh weight of the fruit, weight of the fruit, nut weight per fruit and weight per nut.

The mesocarp of the drupe also yield fibres (7-10%), besides pulp. During selection, if fibre is of major importance palms with a high ratio of fibre to mesocarp flesh and if the preference is for edible purpose, fruits with low fibre content are to be selected.

Besides fruit components, seedling characters also exhibit variations. Among the seedling traits, *viz.*, seedling height, tuber length, leaf length and number of leaves, high estimate of genetic advance is observed in leaf length followed by tuber length which is having a high heritability, implying that these traits are governed by additive gene action. (Table 3). Hence selection of mother palms could also be based on these characters of the progenies.

Table 2. Phenotypic and genotypic variability estimates in fruit characters of palmyrah

Parameters	Mean	Phenotypic variance	Genotypic variance	PCV %	GCV %	Heritability	GA as per cent mean
Fruit weight (kg)	1.049	0.0760	0.0723	26.28	25.63	95.13	5149.67
Flesh weight with epicarp (kg)	0.409	0.0279	0.0273	40.77	40.33	97.85	8232.27
Nut weight per fruit (kg)	0.588	0.0159	0.0152	21.45	20.98	95.74	4231.29
Weight per nut (kg)	0.189	0.0019	0.0018	23.21	22.88	96.36	4639.92

Table 3. Phenotypic and genotypic variability estimates in seedling characters of palmyrah

Parameters	Mean	Phenotypic variance	Genotypic variance	PCV %	GCV %	Heritability	GA as per cent mean
Seedling height	70.37	125.58	70.00	15.92	11.89	55.79	1828.43
Tuber length	21.06	5.87	4.07	11.50	9.58	69.35	1643.22
Leaf length	36.75	109.71	61.02	28.50	21.30	55.62	3625.58
Leaf number	1.89	0.03	0.01	8.58	6.37	55.19	975.18

GCV - Genotypic coefficient of variation; PCV - Phenotypic coefficient of variation; GA - Genetic advance

(after I.R. Suthanthira Pandian and A. Doraipandian, 1991)

PRODUCES AND VALUE ADDED PRODUCTS

PRODUCES OBTAINED

Thavan (spongy haustorium)

Thavan formed during germination of seednut is spongy, sweet and is a delicacy. The weight of thavan decreases slowly beyond 90 days and it looses its palatability and consistency. The weight of thavan range from 25-30 g.

Tuber (apocolon)

The mature tuber is brittle and it breaks off easily and is less fibrous compared to immature ones which are flexible. The tuber is a rich source of starch. The optimum stage for harvesting tuber is 135 days after sowing and the weight of the tuber range from 90-110 g.

Nungu (endosperm)

The jelly like endosperm of young fruit is called nungu. in Tamil. Tender fruits are to be harvested between 60-70 days to get soft nungu. To obtain tender nungu, fruits are harvested when the epicarp near the perianth region is light to yellowish green in colour. Fruits with black epicarp yield only hard and unpalatable nungu.

Fruit

Ripe palmyrah fruits give a sweet aroma and they drop off from the tree when fully ripe. The mesocarp is fleshy and fibrous. The fruit is roasted in fire and consumed. Several value added products can be prepared from the fleshy mesocarp after removing the fibre.

Table 4. Composition of palmyrah fruit

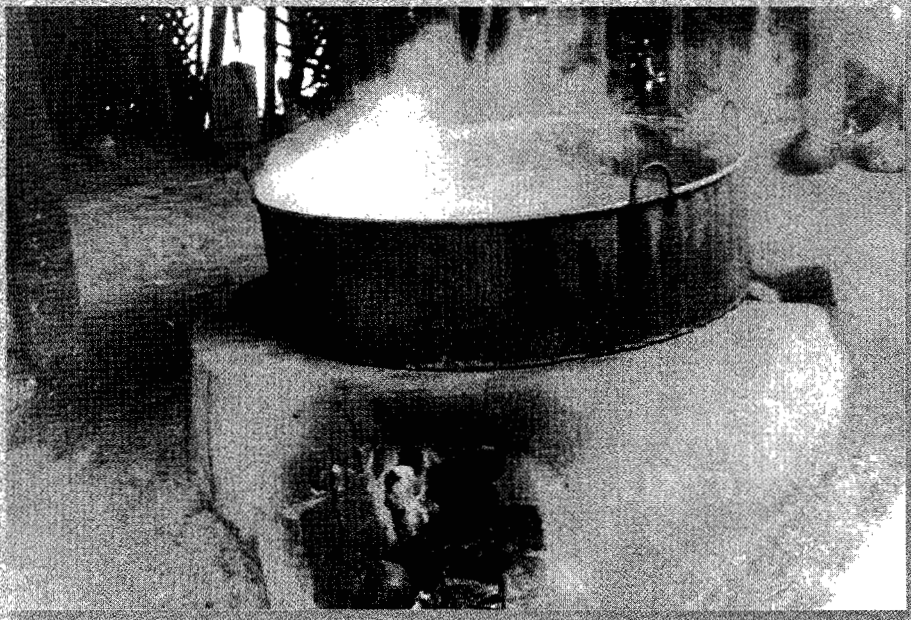
Parameters	Weight (g)	Per cent
Epicarp	89.1	8.7
Mesocarp pulp	108.2	10.5
Fibre	138.3	13.5
Pyrene	690.5	67.3
Whole fruit	1026.1	100.0

PRODUCTS PREPARED

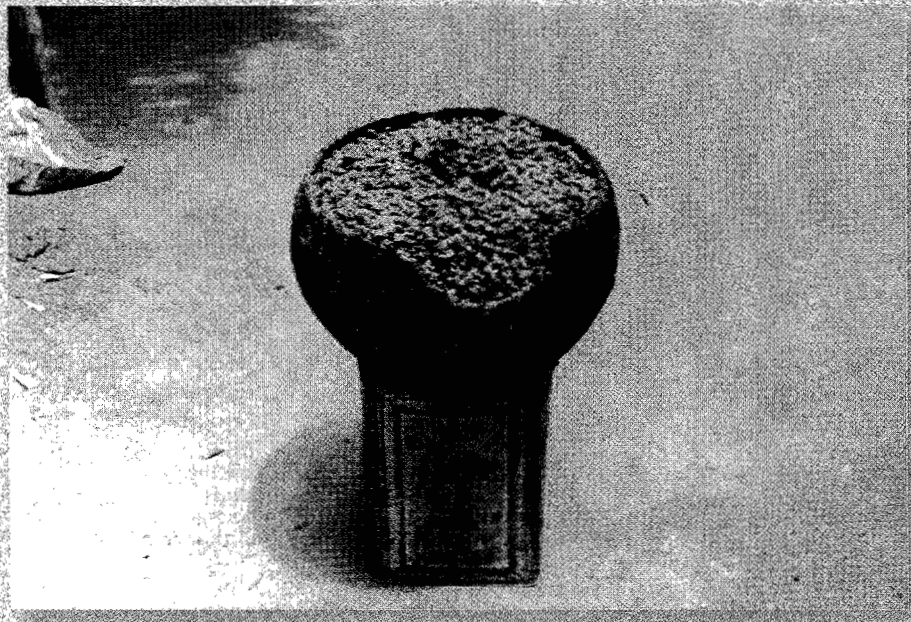
Jaggery

The neera collected from the palm is filtered through a cloth to remove the debris. It is boiled to 110° C in a pan made of galvanized iron (GI). A pinch of coconut kernel or caster seed powder is added to prevent over boiling. Neera gets transformed into a viscous fluid at 110° C. The fluid is stirred continuously to avoid charring at the bottom of the vessel. By placing a few drops of the fluid into cool water, the correct stage of formation of jaggery can be ascertained. The hardening of the fluid in the cold water is an indication of the right

PROCESSING



Neera for Jaggery



Preparation of Palm Candy

stage of conversion of neera into jaggery. The jaggery is poured into coconut shells (cups) to cool. Once solidified, the jaggery is removed from the shell and stored at room temperature. One kg of jaggery can be obtained from 8 litres of neera.

Palm candy

Neera devoid of debris is boiled in an alloy vessel of 22-24 gauge and heated to boiling. When the neera boils, small quantity of superphosphate is added. After attaining uniform boiling, the liquid is removed from the fire and allowed to cool.

The sediments in the liquid are removed again by sieving it through a gauda cloth. The liquid is again heated to 110° C for $1^1/_2$ - 2 hours until it reaches a honey like consistency. It is necessary that the temperature should be maintained correctly for proper crystalisation. The fluid is allowed to cool and poured into crystalisers.

Crystaliser is a vessel in which cotton threads run parallely to promote crystal formation. Crystals get attached to the thread and grow. Crystalisers are kept in shock proof condition, preventing external vibrations. Usually they are burried in sand beds with the mouth of the vessel covered and exposed out.

Sugar crystals will start forming after 45-60 days. Matured crystals will weigh 50-100 g and hexagenal in shape. Fully formed crystals are removed from the thread, washed, cleaned, dried and stored.

Palm honey

After filtering the neera, it is heated in pan made of GI sheet. Heating is done with conventional fuel. To control fast boiling, few drops of coconut oil is added. It takes 2 to 2 1/2 h to obtain the honey like consistency.

Later the syrup is transferred to mud pots. Ripe, dry and shelled tamarind fruits devoid of seeds, with stalks and sutures intact are added into the syrup. About one kg of the fruit is added to 10 litres of the syrup and the pot is closed tightly with a piece of cloth. The vessels are kept in shock proof, cool, dry place for 130-180 days.

Sugar crystalises on the sutures of the tamarind fruits and the fruits become delicious. The mature palm honey resembles honey in taste and colour. The palm honey could be used as a dessert. It also serves as a side dish with bread, iddlies and dosais. Palm honey can also be used to dress ice creams and salads.

VALUE ADDED PRODUCTS

Recipe from Tuber

As palmyrah tuber is a seasonal produce, laboratory techniques have been developed for preparing value added products from the tuber.

Table 5. Nutritive value/100 g of fresh wt. of tuber

Moisture	15.48 g
Protein	2.90 g
Fat	0.56 g
Carbohydrate	67.06 g
Fibre	11.60 g
Ash	2.40 g
Energy (k. calorie)	284.88
Calcium	38.00 g
Phosphorus	99.00 mg

Dehydrated palmyrah tuber

Well matured tubers are selected and the skin removed. The cleaned tubers are boiled, the fibre is removed and the tuber cut into small pieces and sun dried. The cooked and dehydrated tuber is packed in polybags and stored. The dehydrated tuber can be consumed after reconstitution with water or in the powdered form.

Palmyrah tuber flour and rava

Well matured tubers are selected and the outer skin is peeled off. The peeled tubers are cooked by steaming process and chipped. The chips are dried and powdered finally into flour in a mill or coarsely to obtain rava. The flour recovery is found to be 21%. The following products can be prepared from the flour and rava.

i) Palmyrah tuber laddu

Ingredients

Palmyrah flour	100 g
Greengram dhal	100 g
Ghee	50 g
Sugar	200 g
Milk	50 ml

Method

Greengram dhal is roasted in a frying pan and powdered finely. Sugar is powdered and added to the hot and roasted palmyrah flour and dhal mixture. A small quantity of ghee and milk are added and mixed well and made into balls.

ii) Palmyrah - soya laddu

Ingredients

Palmyrah flour	100
Soya flour	100 g
Groundnut	60 g
Jaggery	150 g
Ghee	50 g
Cardamom powder	1 g

Method

Palmyrah and soya flour are roasted finely in ghee and kept aside. Sugar syrup is prepared and when thread consistency is reached, the rest of the ingredients are added and mixed thoroughly until the laddu consistency is reached and then made into small balls.

iii) Palmyrah tuber kesari

Ingredients

Palmyrah flour	150 g
Sugar	300 g
Cashew and Kismis (raisins)	10 g
Ghee	40 g
Water	750 ml
Orange food colour	a pinch

Method

The rava is first roasted finely and kept aside. To the ghee in a pan, cashew and kismis are added. When well roasted, water is added and allowed to boil. To the boiling water the rava is added, stirred and mixed quickly under low flame. When the rava is cooked, food colour and sugar are added and further cooked to kesari consistency.

iv) Palmyrah tuber payasam

Ingredients

Palmyrah flour	100 g
Milk	200 ml
Sugar	200 g
Raisin and cashew nuts	15 g
Ghee	15 g
Cardamom	2 g

Method

The rava is roasted to golden brown and added to boiling water and cooked till soft. Sugar and milk are added to this and further cooked for another 5 minutes. The rest of the ingredients are added and mixed thoroughly and served.

v) Palmyrah tuber idli

Ingredients

Refined wheat rava	50 g
Palmyrah tuber rava	50 g
Bengalgram dhal	10 g
Blackgram dhal	10 g
Oil	10 g
Curd	100 g
Coriander leaves	a few
Curry leaves	a few
Mustard	5 g
Salt	to taste

Method

To the oil, mustard, bengalgram dhal, blackgram dhal and curry leaves are added and seasoned. The rava is added to the above seasoning and fried till slightly brown. Then it is taken off the flame and allowed to cool. Now, curd water and salt are added to the rava and allowed to soak for 3 hours. The batter so prepared is poured into idli moulds and cooked by steaming.

vi) Palmyrah tuber uppuma

Ingredients

Flour	100 g
Onion	25 g
Chillies	5 g
Mustard and blackgram dhal	3 g
Oil	25g
Curry leaves	3 g Salt 2 g

Method

The rava is roasted for 2 minutes and set aside. Spices seasoned in oil, finely cut onions and chillies are added and fried well. To this mixture, three glasses of water and salt are added and let to boil. Finally roasted rava is added and cooked to uppuma consistency.

vii) Palmyrah tuber porridge

Ingredients

Palmyrah flour	250 mg
Water	400 ml
Sugar	75 g
Cardamom powder	a pinch

Method

Palmyrah tuber flour is roasted well and added to boiling water. When well cooked, rest of the ingredients are added and cooked to the consistency of porridge and removed from flame. The above preparation may also be done by deleting sugar and adding 2 g of salt.

viii) Palmyrah tuber pakora

Ingredients

Palmyrah tuber flour	100 g
Bengalgram flour	100 g
Onion	30 g
Potato	100 g
Carrot	50 g
Beans	50 g
Chilli powder and salt	To taste
Oil	200 ml

Method

The vegetables are cut lengthwise into small pieces and mixed with the palmyrah flour, bengalgram flour, chilli powder and salt and is let to stand as such for 10 minutes. Water is sprinkled on the above mixture, mixed well and made into pakoras by deep fat frying.

Recipe from Thavan

Table 6. Nutritive value/100 g of fresh wt. of thavan

Moisture	80.34 g
Protein	0.77 g
Fat	0.18 g
Total sugars	0.85 g
Ascorbic acid	12.2 mg

Thavan after extraction keeps good up to 4 hours. After this an off flavour develops and it becomes unconsumable. However, a few value added products can be prepared from thavan.

i) Thavan peda

Ingredients

Thavan	100 g
Sugar	100 g
Water	250 ml

Method

Fresh and firm pieces of thavan are selected and pricked with a fork. The thavan pieces are then soaked in 2% lime solution for 10 minutes. They are then washed free of lime and cooked in a sugar syrup. When the syrup reaches thread consistency, thavan is removed and shade dried. On drying, the sugar crystalises on the surface of the thavan. Thavan peda thus prepared can be stored in clean dry containers.

ii) Thavan halva

Ingredients

Thavan pieces	200 g
Sugar	200 g
Milk	250 g
Ghee	1 tbsp

Method

The thavan pieces are cleaned, grated and squeezed free of water. The grated thavan is fried in ghee. Milk and sugar are added and cooked to halva consistency.

Recipe from Fruit

The fibre rich pulp of palmyrah fruit is sliced and 500 g of the pulp is dipped in a litre of hot water. When cool, the pulp is squeezed to remove the fibre. The remaining thick pulp is strained to remove fibre if any. A three seeded palmyrah fruit, on an average yields 20 per cent of fruit juice.

Table 7. Nutritive value/100 g of fresh wt. of palmyrah fruit.

Moisture	77.84 g
Protein	0.63 g
Fat	0.17 g
Carbohydrate	20.12 g
Energy (k. calorie)	85,73
Ash	0.64 g
Ascorbic acid	19.00 mg
Calcium	8.98 mg
Phosophorus	33.80 mg
Fibre	0.60 g

i) Squash

Ingredients

Palmyrah fruit juice	750 g
Sugar	2 kg
Citric acid	10 g
Potassium meta-bi-sulphite (KMS)	0.15 g
Water	3 lites

Method

Sugar syrup is prepared with citric acid, cooled and mixed with the fruit juice and KMS. The squash is served with water at a ratio of 3:1.

ii) Ready to serve juice

Ingredients

Fruit pulp	1 kg
Water	7 litres
Sugar	2 kg
Citric acid	10 g
KMS	0.3 g

Method

The fruit juice is extracted and mixed with the sugar syrup solution and KMS, as in the preparation of squash. It is then filled into bottles and stored.

iii) Leather

Ingredients

Palmyrah fruit pulp	250 g
Palm sugar	250 g
Citric acid	5 g
KMS	One pinch

Method

The thick fruit juice of palmyrah fruit is extracted with little water. To this juice, the other ingredients are added and heated to dissolve. The mixture is then poured into a greased plate and let to dry at 30°C in an oven. After solidification, it is then sliced into small chocolate sized pieces, wrapped in butter paper and stored.

Recipe from Nungu

Nungu, the soft jelly like endosperm obtained from the tender fruit of palmyrah is highly perishable and seasonal. However, nungu can be processed and preserved as value added products.

Table 8. Nutritive value/100 g of fresh wt. of nungu

Moisture	92.5 g
Protein	0.6 g
Fat	0.1 g
Ash	0.2 g
Fibre	0.2 g
Carbohydrate	6.4 g
Energy (k. calorie)	28.9
Calcium	12.0 mg
Phosphorus	21.0 mg
Iron	0.3 mg
Ascorbic acid	61.0 mg

i) Nungu candy

Ingredients

Nungu	1 kg
Sugar	1 kg
Citric acid	5 g
Food Colour	2 kg

Method

The nungu pieces are sliced into two halves and pricked with a fork and steeped in dilute lime solution (2%) for one hour. The nungu pieces are removed separately and washed thoroughly in cold water to be free of lime. The pieces are then soaked in a dilute sugar

syrup of 40% TSS for one day and a pinch of food colour is added to the syrup. The next day, the nungu pieces removed from the syrup and the TSS of the syrup is increased to 60° Brix by boiling. The syrup is cooled and the nungu pieces are again soaked in the syrup for 24 hours. The process is repeated and the strength of the syrup is increased by 5% TSS to 75% TSS on alternate days. The nungu pieces are soaked in a syrup of 75% TSS for one week. The nungu is then drained free of syrup and dipped in boiling water to remove the adhering syrup. It is shade dried and cut into small pieces and packed in polybags and stored.

ii) Nungu peda

Ingredients

Nungu	1 kg
Sugar	750 g
Citric Acid	5 g
Lime solution (CaOH)	2%

Method

Tender nungu is selected and the skin is removed. The nungu is sliced into two halves and pricked with a fork and steeped in lime solution for 5 minutes. The nungu pieces are removed separately and washed to be free of lime. The pieces are then dipped in 5% solution of citric acid, washed, further dipped in hot water and removed immediately. The nungu slices, so treated are cooked in sugar syrup until the syrup attains thread consistency. The nungu pieces are removed from the syrup and left to dry in shade. On cooking, the syrup crystallises on the surface and becomes dry . The peda is then stored in aerated boxes made of palm leaf.

iii) Nungu sarbat

Ingredients

Nungu juice	250 ml
Sugar syrup	1 tsp
Lime juice	2 tsp

Method

Tender nungu is selected and the skin peeled. It is further cut into pieces and ground in a blender with little water. Sugar syrup is prepared with a cup of sugar and half a cup of water. Nungu juice and sugar syrup are mixed together. It is served with lime juice.

iv) Nungu kheer

Ingredients

Nungu juice	250 ml
Milk	250 ml
Sugar	to taste
Cardamom	3 pods
Mace	a small piece
Cashewnuts	10 g

Method

Tender nungu is selected and peeled. Nungu is then blended in a mixie with boiled and cool milk. Sugar is added to the above mixture and heated to dissolve. Cardamom and mace are added and the kheer is garnished with cashewnuts and served.

Recipes from Neera

Neera or padaneer is the most economic produce of palmyrah. It has a specific gravity of 1.07 and its pH ranges from 6.7 to 7.2.

Table 9. Nutritive value/100 cc. of neera

Moisture	86.6 g
Protein	350 g
Reducing sugar	998 mg
Ash	0.53 g
Calcium	143 mg
Phosphorus	10 mg
Iron	0.30 mg
Ascorbic acid	15.74 mg
Thiamine	82.3 mg
Riboflavin	44.4 mg
Niacin	674.4. mg
TSS	12.5%

i) Neera khova

Ingredients

Neera	1.5 litres
Milk	2.0 litres
Cardamom powder	a pinch
Cashewnuts	50.0 g

Method

Milk is boiled and cooled. Neera is added to this milk and concentrated by heating to khova consistency. At this stage, cardamom powder is added and mixed well. The khova is spread out in a greased plate and garnished with cashewnuts. It is allowed to set and cut into desired shapes.

ii) Neera pongal

Ingredients

Neera juice	2 litres
Raw Rice	200 g
Palm jaggery	100 g
Cardamom powder	1 pinch
Cashewnuts	20 g

Method

Rice is cooked in neera and rest of the ingredients are added, stirred well and taken off from fire.

iii) Neera payasam

Ingredients

Neera	2 litres
Greengram dhal	100 g
Cardamom powder	1 g

Method

Neera is heated on a low flame for 20 minutes. Rest of the ingredients are added to it and cooked for 5 minutes and served.

STORAGE OF PRODUCES

Since all the edible produces obtained from the palm are seasonal, following methods have been found to be successful in storing neera, jaggery, nungu, fruit and tuber.

NEERA

* Neera free of debris can be stored at room temperature for 8 h by adding 200 ppm of potassium meta bisulphate (KMS)
* Neera can be stored in referigerator up to 15 days without loosing quality
* Neera cleaned from impurities, when heated to 80° C for 10 minutes and stored at room temperature is fit for consumption up to 36 h. When neera is heated to 80° C and cooled to 10° C there is no additional advantage in shelf life.

JAGGERY

* In traditional method, palm jaggery is prepared by boiling neera in a GI vessel. The jaggery so prepared tends to blacken on storage. However, the addition of (KMS) 0.05%, is found to improve the quality and prevent the blackening of jaggery.

NUNGU

Short term storage

* Peeled nungu either blanched or unblanched when packed in vented or nonvented polythene bags can be stored at 5° C for 10 days.
* Nungu with peel in the absence of blanching can be packed in vented polythene bags and stored under refrigerated conditions at 5° C for 10 days without loss of taste. Blanching does not help in improving the shelf life.

Cold storage

* Nungu can be peeled, blanched (3 minutes), packed in polythene bags and stored at -5° C, without loosing colour and flavour up to 60 days.
* Blanched (1 minute) nungu when packed in 100 gauge polythene bags with 25° brix sugar syrup can be stored till 200 days at - 5° C.

FRUIT

* Palmyrah fruit pulp free from fibres can be allowed to freeze as cubes in ice trays of refrigerator. Such cubes can be packed in polythene bags and stored in freezer without loosing flavour and taste up to 30 days.

TUBER

* Flour milled from boiled palmyrah tuber can be stored under room temperature without loss of colour and flavour up to 90 days.

Quality changes in the produces of palmyrah

* Neera kept at room temperature, without heating gets spoiled in 6 h.
* Nungu with peel, without packing when kept at 5° C in refrigerator develops brown skin after 5 days.
* Thavan keeps fresh for 4 h only. The crispness and aroma is lost after 8 h and it becomes unfit for consumption. However, it can be dehydrated at 30-40° C and stored in polybags which can be rehydrated and consumed.
* Palmyrah tubers when stored without peel, begin to decay at their base within 24 h. They can be stored at room tempreture, with peel for 3 days.

CULTIVATION COST (per hectare)

DIGGING PITS

A male labour can dig 15 pits/day

Cost towards digging pits = 1110/15 x 32 = Rs.2368/=

SEEDS AND SOWING

Cost of seednuts = Rs. 0.25 x 1110 = Rs.278/=

Cost of fungicide treatmet = Rs. 0.20 x 1110 = Rs.222/=

Total cost of FYM @ Rs.0.25/kg applied @ 10 kg/pit = 0.25 x 10 x 1110 = Rs. 2775/=

Sowing and covering @ 50 female labourers/ha = 29 x 50 = Rs.1450/=

Total Rs.4725/=

MANURING

Second year	=	FYM 10 kg x 0.25 x 1110	=	Rs. 2775/=
Third, fourth year	=	FYM 20 kg x 0.25 x 1110	=	Rs. 5550/=
Fifth, sixth year	=	FYM 30 kg x 0.25 x 1110	=	Rs. 8325/=
Seventh, eigth year	=	FYM 40 kg x 0.25 x 1110	=	Rs.11110/=
Ninth, tenth year	=	FYM 50 kg x 0.25 x 1110	=	Rs.13875/=
Eleventh, twelfth year	=	FYM 60 kg x 0.25 x 1110	=	s.16650/=

BASIN CLEANING

Female labourers required are 25, 30, 38, 50/ha

First year (cleaning three times) = 3 x 25 x 29 Rs.2175/=

Second to fifth year (cleaning four times once in 3 months) = 4 x 25 x 29 Rs.2900/=

Sixth to eigth year (cleaning four times) = 4 x 30 x 29 Rs.3480/=

Ninth to twelfth year (cleaning four times) = 4 x 38 x 29 Rs.4408/=

Thirteenth year onwards = 4 x 50 x 29 Rs.5800/=

TREE CLEANING

Rate charged are Rs.5, Rs.8, Rs.10/tree

Sixth to eigth year	=	5 x 1110	=	Rs. 5550/=
Ninth to eleventh year	=	8 x 1110	=	Rs. 8880/=
Twelfth year onwards	=	10 x 1110	=	Rs.11100/=

CROP PROTECTION

The palm is a slow grower at early stages and the requirement of spray fluid is less. Leaf spot and black headed caterpillar are of major concern during early stages. (cost of COC = Rs.200/kg; cost of manocrotophos = Rs.300/litre)

Cost of COC 0.2% for six sprays (at two months interval)	=	Rs. 0.10 x 6	=	0.60/palm
Cost of mocrotophos 0.01% for six sprays (at two months interval)	=	Rs.0.08 x 6	=	0.48/palm
Cost of combined application	=	Rs.0.15 x 6	=	0.90/palm
		Total	=	1.98/palm

Rounded off to Rs.2/palm/year

Keeping this cost as a base, since the spray fluid requirement is more as the seedling grows up, Rs.1, 3 and 5 have been added resulting in Rs.3, 5 and 7 in the subsequent years.

In grown up palms, rhinoceros beetle is the major pest and cost of control is as follows:

(Cost of a naphthalene ball = Rs.0.40, cost of malathion 4% dust = Rs.16/kg)

Cost of balls (3) and its application thrice	=	Rs.6/palm
Cost of malathion 4% dust @ 250 g/palm	=	Rs.4/palm
Total	=	Rs.10/palm

This insecticide may be applied while cleaning the tree, so that no separate cost is involved for application.

Costs incurred are Rs.2, Rs.3, Rs.5, Rs.7, Rs.10/tree

Second to fifth year	=	2 x 1110	=	Rs. 2220/=
Sixth to seventh year	=	3 x 1110	=	Rs. 3330/=
Eigth to tenth year	=	5 x 1110	=	Rs. 5550/=
Eleventh to thirteenth year	=	7 x 1110	=	Rs. 7770/=
Fourteenth, fifteenth year	=	10 x 1110	=	Rs.11100/=

WATERING (OPTIONAL)

In the first year, during the non-rainy period of eight months, pot watering can be done once in a week.

Female labourers required	=	25/ha		
Total waterings	=	8 x 4 = 32		
Cost involved	=	32 x 25 x 29	=	Rs.23,200/=

Pitcher irrigation is recommended during the tapping season of four months at twice a month to enhance neera yield.

Cost involved	=	4 x 2 x 25 x 29	=	Rs.5800/ha

TAPPING

Both male and female palms yield neera. As a normal practice the owner of palm gets half the quantity of neera while the tapper takes the other half.

Rate of neera Rs.3/litre

Year	Neera yield/tree (litres)	Neera to tpper (litres)	Total cost
12	60	30	30 x 3 x 1110 = Rs. 99,900/=
13	70	35	35 x 3 1110 = Rs. 1,16,550/=
14	80	40	40 x 3 x 1110 = Rs. 1,33,200/=
15	100	50	50 x 3 x 1110 = Rs. 1,66,500/=

PROFIT

Palms start yielding neera from the twelfth year and the yield gets stabilised from the fifteenth year onwards. Though the yield ranges from100 - 200 litres/season, a conservative yield of 100 litres from the fifteenth year onwards is taken into consideration to work out the profit. Neera fetches a minimum of Rs.3/litre. Besides neera, a minimum of 12 leaves (Rs.0.50/leaf) are obtained from each palm.

Year	Neera yield (litre)	Return from neera/ha	Return from leaves/ha	Gross profit/ha	Expenditure	Net profit/ha profit/ha
12	60	1,99,800	6,660	2,06,460	1,39,828	66,632
13	70	2,33,100	6,660	2,39,760	1,57,870	81,890
14	80	2,66,400	6,660	2,73,060	1,77,850	95,210
15	100	3,33,000	6,660	3,39,660	2,11,150	1,28,510

If palmyrah palm is taken care properly, it can compete with sugarcane to comply our sugar needs. Since the cost towards cultivation of the tree species is much less, the net profit from this perennial tree will be unbelievably high. However, one has to wait for a minimum period of 12 years to see the plam come to bearing.

Cost of Cultivation : Expenditure (Rs./ha)

Year	Digging pits	Seeds and sowing	Manuring	Basin cleaning	Tree cleaning	Plant protection	Tapping	Total	Expense per tree
At planting	2368	4725	–	2175	–	–	-	9268	8.35
2	–	–	2775	2900	–	2220	–	7895	7.11
3	–	–	5550	2900	–	2220	–	10670	9.61
4	–	–	5550	2900	-	2220	–	10670	9.61
5	–	–	8325	2900	–	2220	–	13445	12.11
6	–	–	8325	3480	5550	3330	–	20635	18.63
7	–	–	11100	3480	5550	3330	–	23460	21.14
8	–	–	11100	3480	5550	5550	–	24460	21.14
9	–	–	13875	4408	8880	5550	–	32713	29.48
10	–	–	13875	4408	8880	5550	–	32713	29.48
11	–	–	16650	4408	8880	7770	–	37708	33.97
12	–	–	16650	4408	11100	7770	99900	139828	125.97
13	–	–	16650	5800	11100	7770	116550	157870	142.22
14	–	–	16650	5800	11100	11100	133200	177850	160.23
15	–	–	16650	5800	11100	11100	166500	211150	190.23

Note: Wage for men labour - Rs. 32/-; Wage for women labour - Rs. 29/-

ANNEXURE II

DISEASES RECORDED ON PALMYRAH PALM

Pathogen	Disease	Location
Bertalinia robillardiodes Tassi	Leaf spot	Kerala
Cladosporium borassi Hasija	Leaf spot	Maharashtra
Graphiola borassi Syd. & Butler	Leaf spot	West Bengal, Bihar, Uttar Pradesh, Maharashtra, Andhra Pradesh
Merulius similis Berk & Br.	Root and trunk rot	West Bengal
Pestalotia algeriansis Sacc & Ber.	Leaf spot	Madhya Pradesh
Pestalotiopsis palmarum (Cook) Stay	Leaf blight	West Bengal, Bihar, Maharashtra, Tamil Nadu
Phytophthora palmivora Butler	Bud rot	Andhra Pradesh, West Bengal, Karnataka
Rhizoctonia solani Kuhn	Tuber rot	Tamil Nadu
Stigmina palmivora (Sac,. apud Trelease) Hughes	Leaf spot	Tamil Nadu, Andhra Pradesh

ANNEXURE III

NON-EDIBLE PRODUCES

Stem	Palms of age above 75 years can be felled Hard wood - as timber for construction, furniture Soft wood - fuel in brick kilns Terminal bud - as edible cabbage
Root	Baskets
Tender leaves	Utility , fancy articles and handicrafts
Green leaves	For roofing
Dry leaves	Fire wood
Leaf stalks	Fencing. Yield three types of fibres for utility items
Leaf butt	Fibres for brush
Leaf rachis	Household articles
Leaf lamina	Household, fancy goods
Mesocarp fibre	For stuffing.

EDIBLE PRODUCES - VALUE ADDED PRODUCTS

Neera (sap)	Palm jaggery (gur), palm sugar (candy), palm honey
Tender fruit (nungu)	Candy, peda, sarbat, keer
Fruit	Squash, juice, leather
Tuber	Sweet halva, laddoo, kesari, payasam, idli, pakora
Thavan	Peda, halva.

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Glossary

Accrescent : Enlarged, persistent perianth as the fruit ripens

Acuminate : Narrowing to a point

Adaxially grooved: The surface of a leaf facing stem, which is grooved

Allogamous: Cross-fertilization

Allopolyploid : A polyploid containing two or more different genomes

Allotetraploid: An allopolyploid formed by the doubling of the chromosome numbers in a diploid hybrid

Apically praemorse: Cut (off) at the tip

Autogamous: Self-fertilization

Baculovirus: Non-occluded, bacilliform, DNA virus of family baculoviride, specifically infective to rhinoceros beetle

Bethylid: Hymenopteran, larval, gregarious, ectoparasatiod, effective against lepidopterans and coleopterans

Blanching: Partial cooking by exposing to boiling water or steam for 2 to 5 minutes. Fruits and vegetables are blanched before preserving to soften their texture, destroy enzymes, remove unpleasant flavour or air

Braconid: Hymenopteran, larval, gregarious, endoparasatoid, effective against lepidopterans

Caudate: Tail like appendage

Chlorophyll Stability Index (CSI): Stability of chlorophyll when subjected to an elevated temperature of 56 ±1° C.

Coleoptile: The first leaf of a monocot seedling sheathing the plumule

Coleorhiza: A protective sheath around the radicle of monocot seedling

Connate: Having similar parts fused by growth

Coriaceous: Leathery in structure

Cuneate: Wedge shaped and attached by the point

Dioecious: Plant species in which unisexual (male or female) flowers occur on different plants

Drupe: A fleshy fruit, with a thin epicarp, fleshy mesocarp and a hard endocarp

Eulophid: Hymenopteran, pupal, gregarious, endoparasatiod, effective against lepidopterans

Genetic advance: The improvement in mean genotypic value of selected plants over the parental population. If the value is high, it indicates that the character is governed by additive genes and selection will be rewarding for such a trait

Genotypic variation: The inherent genetic variability in a population consisting of additive, dominance and epistatic components which remains unaltered by environmental conditions. Such variation is measured in terms of genotypic variance

Heritability: The ratio of genotypic variance to phenotypic variance, which is an index of the transmission of characters from parents to offspring

Imbricate: Overlapping

Induplicate: Inwardly folded

Kheer: A sweet made similar to payasam. However, it is highly nourishing, since it contains milk, sugar and nuts. It can be blended with roasted rava, cooked rice or fruits

Kesari: An instant, home made sweet prepared by cooking roasted rava in water, which is cooked further in sugar and ghee to form a firm single mass. This is spread out on a greased plate and cut into desired shapes

Laddu: A common sweet, prepared by mixing sufficient quantity of fried or roasted flour to sugar syrup of thread consistency so as to form a thick dough, which is made into balls

Monoecious: Plant species in which unisexual (male or female) flowers occur on the same plant

Payasam: A major sweet liquid preparation, thick in consistancy. It is a South Indian dish served at all special functions. Roasted rava is cooked in boiling water, milk, sugar, cashew nuts and cardamom are added and served hot or cold

Phenotypic variation: The total or observable variation in a population consisting of the genotypic and environmental components, which is measured in terms of phenotypic variance

Phyllotaxy: Type of arrangement of leaves on the stem

Pinnate: A compound leaf having leaflets arranged in two ranks on opposite sides of the rachis

Pinnatisect: Pinnate with cut ends reaching close to the mid-rib

Plicate: Folded like a fan

Pyrene: The stone of a drupe having a single seed, a single drupe may have 1-3 pyrenes

Reduplicate: Outwardly folded

Relative Water Content (RWC): Amount of water present in a plant tissue when compared to its turgid weight.

Sclerotic exodermis: Hard outer layer of suberized cells on roots

Spadix: A spike of flowers with a fleshy axis enclosed in a spathe

Spathe: A large membraneous bract enclosing a spadix

Stipule: Basal appendage of a petiole/leaf

Thavan: Spongy haustorium of germinating seednut

Theriland: Areas at the contacts of marine and hard rock terrains, degraded due to high wind velocity and shifting sand dunes brought under wasteland, deteriorating for lack of appropriate water and soil management on account of natural causes

Truncate: Blunt ended

Uppuma: An easy to make breakfast dish prepared by seasoning mustard and curry leaf in oil. Water, roasted rava and salt are added to the seasoning and cooked till free of water.