

6. Plantation Crops (HPH 204) 3(2+1)

History and development, scope and importance, area and production, export and import potential, role in national and state economy, uses, industrial importance, by-products utilization, soil and climate, varieties, propagation: principles and practices of seed, vegetative and micro-propagation, planting systems and method, gap filling, systems of cultivation, mulching, shade regulation, weed and water management, training, pruning and handling, nutrition, foliar feeding, role of growth regulators, soil management, liming practices, tipping practices, top working, physiological disorders, harvesting, post-harvest handling and processing, packaging and marketing, yield and economics of coconut, arecanut, oil palm, palmyrah palm, cacao, cashew nut, coffee, tea and rubber.

Practical: Description and identification of coconut varieties, selection of coconut and arecanut mother palm and seed nut, planting of seed nuts in nursery, layout and planting of coconut, arecanut, oil palm, cashew nut, cacao gardens, manuring, irrigation; mulching, raising masonry nursery for palm, nursery management in cacao. Description and identification of species and varieties in coffee, harvesting, grading, pulping, fermenting, washing, drying and packing of coffee, seed berry collection, seed extraction, treatment and sowing of coffee, epicotyl, softwood, grafting and top working in cashew, working out the economics and project preparation for coconut, arecanut, oil palm, cashew nut, cacao, etc. Mother plant selection, preparation of cuttings and rooting of tea under specialized structure, training, centering, pruning, tipping and harvesting of tea.

Plantation Crops

LECTURE 1 PLANTATION CROPS

Definition: A group of commercial crops of perennial nature, cultivated extensively in tropical and subtropical situations which need employment of labour through out the year and the produces of which are usually consumed after processing.

Definition in traditional sense – Plantation crops are those which are cultivated on extensive scale like tea, coffee and rubber. Here the term plantation or estate is used synonymously.

Estate or plantation means large scale agricultural unit usually of a single crop.

Differences between plantation crops vs. fruit crops:

Features	Plantation Crops	Fruit crops
1. Climate under which cultivated	Tropical mainly between 20 ° N and 20 ° S Latitude	Tropics, Subtropics and temperate
2. Necessity of training and pruning	Less	More
3. Suitability for Consumption	Processed and consumed	Major portion is consumed directly in fresh form
4. Perishability of produce	Less/ not perishable	Perishable
5. Export potential /Foreign Exchange earnings	Comparatively high	Some portion of fruits and preserved products are exported.
6. Uses	Diversified: i.e., in medicines, beverages and oilseeds etc	Used mostly as protective foods (Rich in vitamins and minerals)

Important plantation crops

- Oil yielding crops: Coconut, oilpalm, palmyrah

- Masticatory : Arecanut, betelvine
- Beverage crops : Tea, coffee, cocoa
- Nut crops : Cashew nut
- Industrial crop : Rubber

Status of plantation Crops in India

1. **Area and distribution:** Plantation crops have limited geographical distribution and in the world it is largely grown between 20⁰N and 20⁰S of equator.

Area and production of Plantation crops in India 2009-11

STATE/UT'S	Total	
	A (000 ha)	P (000 t)
ANDAMAN & NICOBAR	25.8	62.0
ANDHRA PRADESH	304.2	768.9
ASSAM	88.8	163.7
CHHATTISGARH	33.0	17.0
GOA	82.5	116.8
GUJARAT	16.0	108.0
KARNATAKA	730.5	1777.0
KERALA	968.2	4176.5
LAKSHADWEEP	2.7	40.0
AHARASHTRA	198.2	321.6
MEGHALAYA	12.4	17.1
MIZORAM	6.6	8.2
NAGALAND	1.1	1.6
ORISSA	194.0	274.0
PONDICHERRY	2.2	20.1
TAMILNADU	537.4	3763.3
TRIPURA	10.2	16.4
WEST BENGAL	51.0	276.2
TOTAL	3264.6	11928.2

(<http://nhb.gov.in/statistics/area-production-statistics.html>)

Area and production (Crop wise)

Crop		Are (000ha)		Production (000t)
Arecanut	A	923	P	613
Cocoa	A	400.1	P	478
Coconut	A	46.3	P	12.9
Coffee	A	1895.2	P	10824.3
Tea	A	388.2	P	308.0

Rubber	A	578	P	980.0
Oilpalm	A	171.7		
Total				

Possible area expansion in traditional area is limited. Scope for expansion in non traditional regions is mainly in North and Eastern States.

Area occupied by plantation crops in India = 4 million ha.

=2.8% of total cropped area.

Earnings from export of plantation crops is 27% of total agricultural . Commodities and 4.8% of total export.

2. Topographical situation of plantation crop area in India:

Plantation crops in India are mainly confined to the less populated remote hilly areas of South India, i.e. mainly Kerala, Karnataka and Tamil Nadu.

3. Commercialization of plantations:

Coconut and Arecanut-Being cultivated in India from time immemorial.

Cocoa-from 1960's (Brazilians origin) : However, expansion gained momentum only after 1970's

Oil palm-1970's (African origin): Highest edible oil yielding crop (4- 6 tonnes oil per ha and some times even 8 t/ha)

Cashew- Introduced by Portuguese during 16th Century in malabar coast as Soil Conservation Crop (Brazilian origin). Now India ranks 1st in the world both in Area and production.

Rubber- Mainly in Kerala and Kanyakumari district of Tamil Nadu. Now India occupy 4th position in the world. (4th position in area and 5th position in production)

4. **Yield gap:** There is gap in yield obtained by the farmers and yield reported in Research Stations. Potential yield of crops is very high.

Question Bank :

- 1) Define Plantation crop and differentiate between plantation and fruit crops ?
- 2) Growing of more than one annual or perennial crop in the interspace of main crop is termed as ----- (Multiple cropping)
- 3) Plantation crops are mainly grown for export market . Justify ?
- 4) Plantation crops are grown mainly in South India . Why ?
- 5) List out the important beverage crops with botanical name and family ?

LECTURE 2

Scope and Economic importance of plantation crops

Scope for plantation crops:

1. **Expansion in non-traditional areas:** As population and spice crops have restricted geographical distribution, the possibility of expansion in the traditional areas is limited. However, there is ample scope for expansion of area in non-traditional regions such as North Eastern States where there is irrigation potential. Due to the development of drip irrigation technology new area/non traditional area under plantation crops is increasing.

2. **Export potential:** Plantation crops earn foreign exchange.

Eg. Coir based products ,Coir export and Coffee .

Main products and by-products not only have export prospects but also have considerable internal demand in several ancillary industry. Earning from export of plantation crops accounts to 27% of total agricultural Commodities and 4.8% of total export.

3. **Employment generation:** Cultivation of plantation crops provide year round gainful employment on the farm and factories.

Eg. Coconut provides for 78 man days/ha/yr. Amounting to 70 million man days/year. in Kerala alone.

4. **Crop diversification:** These crops provide ample scope for diversification and there by it creates sustainable agriculture.

5. **Availability of technology and yield gap:** Considerable information on recent technologies are available on these crops.

Eg. CPCRI Kasargod, Kerala.

NRC on Cashew, Shantigod, Puttur (D.K). and Various Agril. Universities, Res. Stations etc.

Economic importance of plantation crops:

1. **Export earnings:** Plantation crops occupy less than 3 per cent of the total cultivated area (i.e. 1.82 per cent of total crop land – 4 million ha. out of 143.00 million ha. i.e. around 2.3%).

2. **Leading position in the world:** India is leading in the total production of certain plantation crops in the world.

Eg: Tea, Cashew, Arecanut, Coconut and Rubber.

3. Employment opportunity: Plantation crops provide direct and indirect employment to many people.

Eg: Tea- 20 lakhs people-

Cashew-5 lakhs people

4. Industrial importance: Production industry supports many byproduct industries and also many rural industries.

Eg: Coconut Fiber (obtained from husk) production in India is about 2.2 lakh tones.

5. Conserving soil and ecosystem:

Eg: Tea and coffee with shade trees planted on hill slopes

Cashew in barren and waste lands – Both are protect soil from water and wind erosion.

Important Research Stations on Plantation and Beverage Crops

Coconut : Central Plantation Crop Reserch Institute , Kasargode, Kerala

Arecanut : CPCRI, Regional Research Station, Vittal, Karnataka

Cocoa - CPCRI, Regional Research Station, Vittal, Karnataka

Rubber: Rubber Research Institute of India, Kottayam, Kerala

Cashew : Directorate of Cashew Research, Puttur, Karnataka

Oil Palm : National Research Centre, Elur, Pedavegi, Andhra Pradesh

Palmyrah : Srivaliputtur, Tamil Nadu

Tea : Tea Research Institute, United Planters Association of South India (UPASI), Valparai, Tamil Nadu

Coffee : Central Coffee Research Institute, Balehonnur, Karnataka

Question Bank .

- 1) List out the economic importance of plantation crops ?
- 2) Mention research Stations working on beverage crops ?
- 3) Where is the headquarters of CPCRI ?
- 4) Which are the identified non traditional areas for area expansion under plantation crops ?
- 5) Mention the plantation crops in which India is in leading position in the world ?

LECTURE 3

ARECANUT (*Areca catechu*)

Fam: Palmae / Arecaceae

Introduction

A tropical palm mainly cultivated and used in Indian subcontinent for mastication.

Research Centres working on arecanut

- 1) CPCRI Regional Station, Vittal.= Started in 1956.
- 2) CPCRI Research Centre, Hirehalli (Tumkur)
- 3) CPCRI Research Centre, Peechi (Kerala)
- 4) CPCRI Research Centre, Mohitnagar (W.B)
- 5) CPCRI Research Centre, Kahikuchi (Assam)

CPCRI Research Centre, Palode (Kerala)= Here main work is on YLD. **Alkaloids present in arecanut**

Arecoline is the main and physiologically most active alkaloid present to an extent of 0.07 to 0.1 per cent.

1. Masticatory use: Betel or pan.

2. Socio religious uses:

3. Medicinal uses:

Origin and Distribution of arecanut

Origin:

World: India, Sri Lanka, Malayasia, Philippines, Thailand, Burma and Bangladesh.

In South East Asian countries it is a stray crop. Only in India it is under scientific cultivation.

India is the world's largest producer of arecanut contributing nearly 74 % towards world production.

World Arecanut production during 2009

	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
India	387100	12433	481300
China	47881	41647	199413
Myanmar	53000	22641	120000

Bangladesh	176350	5979	105448
Indonesia	128000	4687	60000
Sri Lanka	14220	19592	27860
Thailand	19060	14291	27240
Bhutan	5700	11184	6375
Nepal	2098	18956	3977
Malaysia	1468	13474	1978
Kenya			97
Maldives	1	30000	3
Total	834878		1033691

FAOSTAT 2009

India : As per 1994-95 statistics. (Too old)

Area : 2.54 lakh ha

Production : 3.0 lakh tonnes

As per issue of *Indian Horticulture* January to March 2001.

India is the world's largest consumer of arecanut (**accounting to 89 % of world production**)

Important arecanut growing states

states	Area (000 ha)	Production (000t)
KARNATAKA	184.5	224.0
KERALA	97.2	112.1
ASSAM	70.0	62.7
WEST BENGAL	11.4	21.2
MEGHALAYA	12.4	17.1
TAMILNADU	5.0	10.4
TRIPURA	4.4	8.4
MIZORAM	6.6	8.2
ANDAMAN & NICOBAR	4.1	6.0

MAHARASHTRA	2.2	3.6
GOA	1.9	2.8
Total	400.1	478.0

Source: www.nhb.gov.in

Present Status and Future Policy for arecanut

1. We have attained self sufficiency in our requirement: The area and production of arecanut in India showed an increasing trend during past 40 years
2. Uses of arecanut other than chewing are negligible: Now research is going on to find out medicinal uses and better alternate uses of arecanut
3. Limited export potential: People of only Asian origin are habituated for arecanut chewing but not western people.

Future Policy (Suggestions are for intensive cultivation by);

1. Taking up of replanting and under planting in the age and unproductive plantations. Arecanut palms live for about 60 –100 years but economic yields are attained up to 30 –45 years depending on conditions of management.
2. Multiple cropping – Inter and mixed cropping in arecanut plantation to augment the income from existing plantations.

Climatic requirement)

Agro climatic zone

Arecanut is being grown in the zone 12 consisting of Western Plains and Ghats as well as the North Eastern Hills.

Temperature

The temperature should be a minimum of 4°C (at Mohitnagar in West Bengal) and a maximum of 40°C (at Vittal in Karnataka and Kannara in Kerala). However, the palm flourishes well within a temperature range of 14°C to 36°C.

Rainfall

Arecanut requires abundant and well distributed rainfall. It grows well in tracts of very high rainfall, where annual showers may go up to or even more than 4500 mm. But it also survives in low rainfall areas having 750 mm annual precipitation. During prolonged dry spell palms should be irrigated.

Soil

Arecanut cultivation is predominant in gravelly laterite soils of red clay type of Southern Kerala and Coastal Karnataka. Arecanut needs deep and well-drained soil preferably not less than 2 meters, for development of root system. Laterite, red loam and alluvial soils are most suitable. In plain region or Maidan part of Karnataka, it is cultivated in fertile clay loam soils. In areas where tank irrigation is common practice, the soils may have admixture of tank silt. Deep black fertile clay loam soils supported luxuriant palm growth.

Question Bank

- 1) Main centre working on arecanut is located at _____ (Vittal, Karnataka)
- 2) Main alkaloid content in arecanut is _____ (Arecoline)
- 3) Uses of arecanut other than chewing is limited. Justify
- 4) Major state growing arecanut in India is _____ (Karnataka)
- 5) Arecanut has limited export potential. Justify ?

VARIETIES

A. Cultivars of arecanut:

(source:<http://www.cpcri.gov.in/farmer.htm>)

Cultivars of arecanut are known by the place where they are grown.

Mangala

It bears early with more number of female flowers per inflorescence, higher nut set. It stabilizes quickly in comparison with local South Kanara variety. The cultivar was released by CPCRI for coastal areas of Karnataka and Kerala upto an altitude of about 800 meters above MSL.



Sumangala

It is a tall type with partially drooping crown. Under good management, palms flower in 4-5 years. The colour of the ripe nuts is deep yellow to orange and oblong to round in shape. The variety recorded an average yield of 17.25 kg of ripe nuts per palm per year at the age of ten years. It was released by CPCRI.

Sreemangala

Arecanut palm is tall with partially drooping crown with longer internodes and sturdy stem. It starts flowering in 4-5 years. It is a high yielder with an average yield of 15.63 kg ripe nuts per palm per year. Ripe nuts usually oblong to round in shape with deep yellow colour. It was released by CPCRI.



Mohitnagar

The variety is consistent high yielder with an average yield of 15.08 kg ripe nuts per palm per year. This variety is released by CPCRI for cultivation in West Bengal and Coastal areas of Karnataka and Kerala.

Kahikuchi Tall

A high yielding variety, Kahikuchi (VTL-64) has been released for Assam and NEH region. Nuts are bigger and heavier with high recovery of chali/ dry kernel (25.2 %) from fresh nuts. The average yield of this cultivar is 3.70 kg dry kernel per palm per year.





Swarnamangala

Tall type with partially drooping crown, flower in 4-5 years, longer internodes, sturdy stem, orange to deep yellow colored and oblong to round shape nuts. Average yield (Chali/palm) : 3.90 Kg. It is released for irrigated areas of Karnataka and Kerala.

South Kanara Local/Kasaragod Local

It is largely grown in Dakshina Kannada district of Karnataka and Kasaragod district of Kerala. It is characterised by large sized nuts with uniform bearing and the average chali yield is about 2.0 kg/palm/year. Ripe nut of this cultivar is mainly used for making chali.





Calicut-17

The striking features of this cultivar is its consistent and high yielding potential (average yield of 18.89 kg ripenuts per palm per year with a kernel wt. of 4.34kg per palm per year), well placed bunches with round and bold nuts. This cultivar has been released for commercial cultivation in Andaman and Nicobar group of islands.

SAS-1

This variety is characterized by tall palm with compact canopy. Nuts are round and even sized and closely arranged on compact bunches. Also it is suitable for both tender and ripe nut processing. It has got the potential to yield about 4.60 kg chali per palm per year. The variety has been recommended for traditional arecanut growing valleys of Sirsi hill zone of Karnataka.





Shriwardhan

It is grown widely in the Raigad and Rathnagiri districts of Maharashtra and Coastal Karnataka. The nuts of this variety are oval in shape and the yield is comparable to 'South Kanara'. Average yield recorded is about 2.20 kg chali/palm/year. Due to its shape and marbled appearance of the kernel when cut, it fetches premium price in the market.

Sagar

It is mainly grown in Uttara Kannada and Shimoga districts of Karnataka. It is a tall type and having sturdy stem with erect bunches are the distinguishing characters of this cultivar. The nuts are smaller in size and round in shape. Average yield 2.25 kg chali/palm/year. Nuts are used for making both chali and tender nut processing.



Thirthahalli

It is grown extensively in Malnad areas of Chikmagalur and Shimoga districts of Karnataka and ripe nuts of this cultivar preferred for tender nut processing. The size of the nuts are smaller and oblong in shape. Its yield is about 12 kg ripe nut/palm/year.

Vittal Areca Hybrid -1

It is early bearer, dwarf with partially drooping crown, well spread leaves, sturdy stem, medium size, oval shape and yellow to orange coloured nuts. It reduces cost of cultivation, harvesting and spraying easy. Average yield (Chali/palm): 2.54 Kg. It is released for coastal Karnataka and Kerala.



Vittal Areca Hybrid -2

It is early bearer, dwarf with partially drooping crown, well spread leaves, sturdy stem, medium size, oval shape and yellow to orange coloured nuts. It reduces cost of cultivation, harvesting and spraying easy. Average yield (Chali/palm): 2.64 Kg. It is released for coastal Karnataka and Kerala.

Selection and Raising of arecanut Planting material

In arecanut we have to have selection at different levels to get better result i.e.,

- 1. Selection of seed plantation :** The plantation should be from disease free and having higher proportion of regularly high yielding palms.
- 2. Selection of mother palms :** One of the established method of selection is to select palm possessing characters of high heritability.

a) Earlyness in bearing and percentage of fruit set : Of the several characters of mother palm studied age at first bearing and percentage of fruit set were found to be correlated with yield and are having high heritability. Age at first bearing has heritability of 72 per cent and genotypic correlation of – 0.55 with yield (Number of nuts). Similarly percentage of nut set has 0.88 genotypic correlation with yield and 33 per cent heritability. Hence, it is suggested to select palms which are early bearing and have high percentage of fruit set .

b) Age of palms: Middle aged palms : Collection of nuts from the selected palm can be commenced after the stabilization of yield which normally takes 4 – 5 years after commencement of bearing. Hence, select middle age palms (15 – 35 years) with robust crown

c) It must be regular bearing

d) Select palms having large number of leaves on the crown

e) Palms with shorter internodes are preferred

3) Selection of seed nuts : Heavier nut (> 35 g fresh nut weight) which are fully ripe are selected. Undersized and malformed nuts should be rejected. Heavier nuts with in a bunch not only give higher per cent of germination but also produce vigorous seedlings of better quality. Above 25 per cent of nuts with in a bunch are light in weight.

4) Selection of seedlings : Twelve to eighteen months old seedlings are transplanted in the main field. Nuts germinate in 53 to 94 days (2-3 months) after sowing.

Seedling Index in arecanut : It is observed in arecanut that,

There is significant positive genotypic correlation of number of leaves and negative correlation of height at the time of transplanting with subsequent yield it is suggested to select seedlings having maximum number of leaves and minimum height (Bavappa., 1970).

Seedling Index = (Number of leaves X 40) – Plant height (cm)

Seedlings having higher value of seedling index should be select to the extent practically feasible.

Question Bank :

- 1) Mention the name of two arecanut hybrids ? (Vittal Areca hybrid-1 and Vittal Areca Hybrid -2)
- 2) What do you mean by seedling index in arecanut and give its formula ?
- 3) Higher the seedling index better will be the selection – True or False (True)
- 4) Minimum weight of nut for raising arecanut seedling is _____ (35 g)
- 5) Mention the features of mother palms in arecanut ?

Establishment of Plantation

Successful establishment of arecanut plantation depends on

- 1. Provision of protection against sun scorch and
- 2. Perfect drainage

Drainage channel is dug for every two rows of arecanut.

Depth of drainage channel = At least 15 to 30 cm deeper than the depth of planting.

Note

- : 1) Clean drainage channels at the onset of monsoon every year. And
- 2) Provide out lets for the flow of water from pits.

1. Planting time :

May –June = In well drained soils /Low rainfall areas

August – September = In clay soils subject to water logging/ In heavy rainfall areas.

- 2. Spacing and alignment:** Different methods of planting, viz., Square, rectangular and quincunx are in vogue. Aligning in N-S direction and planting on quincunx system or square system lowers the incidence of sun scorch.

Spacing = **2.7 m x 2.7 m**

Arecanut needs adequate protection from Southwestern sun (October to Jan.) to minimize sun scorching of the stem. This can be attained by ;

- ➔ 1. North South line should be deflected at an angle of 35 ° towards west.
- ➔ 2. Growing of tall and quick growing ever green perennial shade trees on western and southern borders. Eg. *Acacia auriculiformis*, Jack, Kokum, neem, Casurina, Pongamia etc.
- ➔ 3. Tying of areca leaves or areca leaf sheath on the south western exposed portions of stem.
- ➔ 4. White washing with lime slurry.

Planting

Deep planting

Planting pits of 75 to 90 cm deep is necessary in areas where

- ❖ Provision of drainage can be made or

- ❖ Areas having well drained soils

Shallow planting

Planting pits of 45 to 60 cm deep is done in areas where

- ❑ 1. Soils are heavy and
- ❑ 2. Impedance/ obstruction for the proper drainage

Nurse crop/ shading

During hot weather starting from October, young seedlings may be protected against direct exposure to sun by;

- **Artificial shading** : With either coconut or arecanut leaves or by raising
- **Nurse crop**: Eg. Banana

Season of sun scorch: Between October to January

Question Bank :

- 1) Drainage channels in arecanut must be deeper than depth of planting – True or False (True)
- 2) Depth of planting in arecanut varies with soil type . Justify ?
- 3) Mention the spacing recommended for growing arecanut ?
- 4) What do you mean by Nurse crop. ?
- 5) What do you mean by sunscorching in arecanut ?

MANURING IN ARECANUT

A) Organic manure

FYM / Compost/Green leaf/Cattle manure = 20 kg per palm per year.

B) Fertilizers:

Recommended dose : 100 g N : 40 g P₂O₅ : 140 g K₂O per palm per year applied in two equal splits i.e.,

- 1) Pre monsoon = May – June
- 2) Post monsoon = September - October

Note: Apply 1/3 of recommended dose after one year of planting and 2/3 at the age of 2 years and full dose from 3rd year onwards.

Method of fertilizer application

I dose = May – June.: Broad casting of fertilizer

Weed out and broad cast around the base and mix with soil by light soil working/forking.

II dose = (September-October) : Basin application

Dig out basins of

Depth = 15 – 20 cm and

Radius = 75 to 100 cm leaving 20 cm from the base of the palm.

IRRIGATION IN ARECANUT

Water requirement for areca

December to February = 12 liters per palm per day

March to May = 20 liters per palm per day.

Irrigation intervals

In West coast (Major arecanut growing area) interval of irrigation recommended are (@ 175 liters per palm per irrigation).

November – December = 7 – 8 days

January – February = 6 days

March – May = 3- 5 days

Systems of irrigation in arecanut

I. Traditional /Earlier methods

- a) Bunding and storing water in drainage/irrigation channels. Water is allowed to percolate.
- b) Splashing : Splashing water guided in to irrigation channels. Irrigation channels are usually of 20 cm deep and 45 cm wide.

II. Modern methods

- ➔ a) Sprinkler irrigation and Perfo methods : It is suitable for high density areca based multicropped plantations.
- ➔ b) Micro irrigation
 - i) Drip irrigation and
 - ii) Micro sprinkler irrigation

Drip Irrigation

Dripper or emitters are to be placed at a distance of 0.40 to 0.60 m away from the arecanut. The extra cost incurred on drip can be regained in 3- 4 years due to saving in water and increase in yield.

Cover cropping in arecanut plantations

Used in areas where soil erosion is a problem i.e., heavy rainfall areas. Cover crops kills/suppresses weed growth during rainy season.

Green manure cum cover crops in areca plantation

1. *Mimosa invisa* = Thorneless mimosa,
2. *Stylosanthes gracillis* ,
3. *Calapogonium muconoides*,

The land always desires to be with crop cover(, i.e., sashya shamale as mentioned in our national song)

Mulching:

Mulching and its advantages in arecanut plantation;

German word Molsch = soft to decay ,

In general mulch refers to the use of straw or leaves spread over ground.

Materials commonly used for mulching are

- Crop residues like husk, peels, etc
- Straw
- Leaves
- Paper
- Plastic films and
- Dry soil etc

Season of mulching: The base of the palm & interspace is mulched during summer months.

Multiple cropping in arecanut plantations

Growing of crops in association with arecanut and coconut is an age old practice. Venation structure and orientation of fronds permits adequate solar radiation falling on the fronds to percolate below facilitating multiple cropping.

Rooting pattern of palms also provides scope for taking up of component crops either as intercrop or as mixed crop. However, these crops are to be adequately and separately manured in addition to the manures applied for arecanut.

Considering the

- 👤 long pre bearing age of 5 to 8 years in arecanut,
- 👤 the low income in the early period of bearing and
- 👤 the fluctuation in the market prices of arecanut from year to year,

it is worth to take up inter cropping in the plantation. The practice helps the arecanut growers to get additional income and to cover the risk of poor yields from arecanut resulting from unfavorable weather conditions and incidence of pest and diseases.

The choice of intercrops depend on its ability to tolerate shade and to withstand the heavy dripping from arecanut palm during monsoon showers. Crops grown as associated mixed/intercrop should result in minimum competition with arecanut for their nutrient requirements. Several crops are reported as component crop with arecanut in a plantation under different agroclimatic conditions

Multiple Cropping: When it is referring to plantation crops it denotes growing more than one annual and or perennial crops in the inter space of main crop.

Intercropping: As applied to plantation crops refers in growing of annuals or biennials in the inter space of main crop.

Eg Turmeric, ginger, elephant foot yam, tapioca, dioscorea, sweet potato etc are grown in areca based intercropping systems :

Mixed cropping: As applied to plantation crops refers to growing of perennials along with the main crop.

Eg of arecanut based mixed cropping systems: Banana, cocoa, pepper, betel vine,

Multi storeyed cropping: Refers to the compatible combination of crops having varying morphological frame and rooting habits, grown together in such a way that, their canopies intercept solar energy at varying heights and the roots forage the soil mass at different zones/depths.

Eg of arecanut based multistoreyed cropping systems:

Nurse crop: Are annuals or perennials grown during the early years of plantation crops with a view to protect them against scoring wind or frost damages.

Eg. Banana crop grown in the initial stage of arecanut plantation.

Plant protection in arecanut

A) Pests:

1. Mites (Red and white)
2. Spindle bug
3. Root grub
4. Tender nut drop
5. Thrips :

B) Diseases:

1. Koleroga, mahali or fruit rot
2. Bud rot,
3. Inflorescence die back and button shedding,
4. Anabe roga/Foot rot
5. YLD
6. Leaf blight,

C) Physiological disorders:

1. Hidimundige or band disease due to a) water logging b) High acidity and c) Hard sub soil strata.
2. Nut splitting and
3. Sunscorch/stem breaking

A) Pests

1. Root grub in arecanut

(White grub/Root grub: *Leucopholis burmeisteri* Brenskii)

The grub : The grub is characterized by  shaped soft body with brown hairy legs.

Stage of attack : Larvae of beetles.

Method of damage : Feeding on tender roots → Followed by older roots

Symptoms :

- 🐛 Tapering of stem,
- 🐛 Yellowing of leaves and
- 🐛 Dropping of fruits

Season of occurrence: May – June to February – March in moist soils

Control / Management:

- 1) Improving drainage,
- 2) Keeping plantation clean and free from weeds, un decomposed Organic matter or FYM
- 3) Chemical control:

Soil insecticides like Phorate / Thimet 10 G are used at 8g to 15 g per palm twice in a year i.e., May-June and September – October

Question Bank :

- 1) Arecanut requires ___ litre of water per palm per day under drip system during hot summer (20 litres)
- 2) Recommended dose of potassium for arecanut is _____ g per palm per year in yielding stage (140 g)
- 3) Mention the purpose of growing cover crops in arecanut ?
- 4) Which are the recommended cover crops for growing in arecanut plantations ?
- 5) What do you mean by multistoreyed cropping in arecanut ?

LECTURE 7

B) Diseases

1) Koleroga or Mahali or Fruit rot of arecanut:

Cause : *Phytophthora arecae*

Season: Monsoon, High humidity alternating with bright sunshine and rain.

Symptoms: Water soaked lesions on the surface of fruit. Later the lesions spread over to other lesions giving dark green colour.

Neergole: → Initial symptom

Boosargole: → Later stages

Control of Koleroga in arecanut:

1) Spraying of Bordeaux Mixture (1 %) as prophylactic or preventive spray

I Spray = Onset of monsoon (i.e., After first monsoon showers)

II spray = 40 to 45 days of first spray and there after if necessary

III spray = If necessary

In place of Bordeaux mixture we can also use COC (Copper Oxchloride) /Blitox @ 3 g per liter of water can be used.

2) Collection and removal of affected plant parts and burning → To reduce the inoculum

Note : Entire surface of nuts has to be covered fully which can be achieved by applying the solution as a very fine spray.

3) Tying of plastic bags/straw/Areca leaf sheath: The fruit bunches at different stages of maturity are tied with plastic bags/straw/Areca leaf sheath at the onset of monsoon after drenching with 1 per cent Bordeaux Mixture.

C) Physiological disorders arecanut:

1) Band or hidimundige disease:

Band = barren (in marathi).

This disease is a major problem in Konkan Coast of Maharashtra. Diseased palms ceases to produce fruits.

It is known as hidimundige disease in Karnataka

In Sri Lanka = Pencil point disease and in

LECTURE 7

Australia = Rosette disease

Symptoms :

1. Production of smaller leaves and ultimately crown forms a rosette shape
2. Reduction in internodal length and tapering of stem towards apex
3. Mostly unproductive :nuts if at all produced are small and malformed.

Etiology :

- 1) Poor drainage and low fertility of soil
- 2) Sub soil pan / hard clayey pan

Control :

- Better soil management and improvement in drainage.
- Removal of hard pan on the sub soil and foliar application of micronutrients,
- Correction of soil acidity and incorporation of mixture of copper sulphate and lime.

2) Nut splitting in arecanut:

A physiological disorder of universal occurrence in almost all gardens. It is purely physiological. The growth of pericarp does not keep pace with the development of kernel inside and thus causing the splitting up of the pericarp and distal end. The split nuts drop. Infection of bacteria and fungus of the exposed kernel after splitting renders the nuts useless.

Symptoms:

Premature yellowing of nuts when they are $\frac{1}{2}$ to $\frac{3}{4}$ matured. It is seen in patches in individual plantations and common on young palms.

Cause/ Reasons.: Excessive flow of cell sap into the inflorescence in very healthy palms.

- Excessive flow of sap in to the inflorescence
- Excessive nutrient supply
- Prolonged drought followed by sudden irrigation

1)Application of borax @ 2 g per liter of water (0.20 % spray) on bunches during early stages of disease. and K_2O at the base is found to check nut splitting to a certain extent.

2) Improvement of drainage and provide regular irrigation during drought

LECTURE 7

2) Sunscorch and stem breaking:

Cause: Due to adverse effect of solar radiation., i.e., palms exposed to the south western sun are affected.

Symptoms

Stem: Golden yellow spots which later turn brown. In advanced stages fissures develop at these points. Further, saprophytic micro organisms and insects harbour in these portions leading to breaking of stem at later stages.

Management/Protection

1. Tying areca sheath or leaves on the stem being exposed to Western and southern sun.
2. Planting of quick and tall growing shade trees on the south – western side of the garden. Eg., Ever green trees like Kokum (*Garcinia indica*), Jack,
3. Adoption of proper alignment while planting to minimize the damage due to scorching.

Question Bank

- 1) Mention any two physiological disorders in arecanut ?
- 2) What are the reasons for Hidimundige in arecanut ?
- 3) Suggest management practices for sunscorch protection in arecanut ?
- 4) Which is the major disease of heavy rainfall areas in monsoon? (Fruit rot/ Kole roga)
- 5) Spraying of _____ micronutrient is suggested for the management of nut splitting in arecanut (Boron)

LECTURE 8

Harvesting, Processing and yield

Season of harvesting : For *chali* = November to March (From blooming to maturity it takes 9 to 11 months)

In arecanut the stage of maturity of nut at harvest varies depending on the type of produce that is to be prepared. There are two category of arecanut based on the method involved in processing;

Kottapak consumed mainly in North India and in Gutkha industry

Kali pak consumed mainly in South India

1. Ripe nut harvesting for chali/ Kottapak preparation :

From blooming to maturity it takes 9 to 11 months and these nuts are harvested (Usually from November to March) , sundried and dehusked to prepare *chali*.






Stage of harvesting for chali : Ripe nuts i.e., when green nuts turn orange yellow and husk becomes soft.

Processing

I. Ripe nut processing in arecanut (Kottapak) i.e., *chali* (dried ripe nut) : It is dried ripe whole nut. In *chali* preparation only ripe nuts are harvested. The out turn of *Patora* or Koka (lower grade produce) will be more if unripe nuts are harvested, which will fetch low price in the market. Fully ripe nuts are harvested (more than 9 months stage of maturity depending on the agro climatic conditions) from November to February and are sudried for about 40 to 45 days→ Dried arecanuts are dehusked . Proper drying of the nuts is important to prevent fungal infection of the nuts in the drying yard.

Chali preparation is mainly in Kerala, Karnatakam Assam and Maharashtra

Characters of good *Kottapak* :

-  1. Absence of immature nuts,
-  2. Absence of surface cracking
-  3. Absence of husk sticking
-  4. Free from fungus and insect attack : Inadequate/improper drying leads to fungal infection and poor quality produce.
-  5. Good cutting feel, inside structure and taste

LECTURE 8

II. Tender nut processing/ Kalipak preparation : It is done mainly in

- 🌿 Kerala and
- 🌿 Karnataka (i.e Theerthalli type grown in Shimogga) and is consumed largely in South India.

Processing for Kalipak:

1. **Nuts are harvested at 6 to 7 months stage of maturity.** At this stage the outer skin of the husk is dark green and nuts are soft and finger nails can be pressed into it.
2. **Dehusking :** Separation of husk from kernels
3. **Cutting** of soft nuts into pieces.
4. **Boiling** – Cut pieces of nuts are boiled in water in a container till the water becomes thick syrup. We can also use dilute extract from previous batch of boiling.
5. **Kali or chogaru coating :** Kali is the extract obtained during boiling of tender nut. Usually the same water is used for boiling 3 to 4 times. At this stage the water becomes concentrated called Kali. After boiling the arecanut are given coating with Kali to improve colouring. Kali coating is repeated to get glossy appearance. Kali contains many polyphenols.
6. **Drying:** It can be dried under sun or in an oven after draining the adhering liquid.
7. **Colouring:** Faulty drying ,exposure to rain or delay in boiling results in bleached appearance to nuts due to lack of proper colouring. Thick syrup of Kali or chogaur is used to colour these dried nuts.

A well dried product of Kalipak will have;

- 🌿 Dark brown colour
- 🌿 Glossy appearance
- 🌿 Crisp chewing feel
- 🌿 Well toned astringency and
- 🌿 Absence of over matured nuts.

Yield: Depending on the cultivar about 2 kg *chali* can be obtained per palm.

Initial yield is at 5-6 years age

Economic yield is at 9-10 years age

Economic life is upto 30-40 years

LECTURE 8

Kottapak consumed mainly in North India and in Gutkha industry

Kalipak consumed mainly in South India

Question bank

- 1) Mention two stages of harvesting in arecanut for the processing of Kottapak and Kalipak ?
- 2) Mention the characteristics of good kalipak?
- 3) Mention the characteristics of good kottapak ?
- 4) Pre bearing age in arecanut is about _____ years (5 to 6 years)
- 5) Average yield per palm per year of kottapak / chali grade of arecanut is _____ (2 kg)

Coconut

Cocos nucifera L. Family : **Arecaceae.**

It is considered as **Kalpavriksha** as it provides the basic necessities of life.

Coco = Spanish word meaning monkey face (probably refers to the three scars on the base of the shell resembling two eyes and a nose of monkey face.

In the current situation of edible oil shortage there is enormous scope for improving the

- Existing plantations (intensive cultivation) : can be increased by four folds and
- Extending the area under the crop
 - ➔ Commercial plantations and
 - ➔ House yards,

Average national coconut productivity = 40 to 50 nuts per palm per year.

Research and Development on coconut in India

CPCRI: The important organizations conducting research on coconut in India include Central Plantation Crops Research Institute under ICAR and state Agril. Universities.

Mandate crops of CPCRI are coconut, arecanut and cocoa. It also co-ordinates research on the mandate crops within the country through AICRP on palms

Origin of coconut :

Malaysia or Indonesia are the probable place of origin of coconut. Although the original home of coconut is still not precisely known, two distinct regions, South Pacific Islands of Polynesia and Melonesia at South East Asia are often cited as possible centres of origin from where it might have disseminated to other areas. Tamils together with the mariners of the Bengal Coast distributed it into the lands of the Indian Ocean.

Distribution of coconut

World

Indonesia, Philippines, India, Sri Lanka, Thailand, Malaysia, Papua New Guinea (by the side of Indonesia, but in Australian Continent), Fiji etc.

Area and Production of coconut in the world

Country	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
Indonesia	3231710	66731	21565700
Philippines	3401500	46060	15667600
India	1903000	53326	10148000
Sri Lanka	394840	53160	2099000
Brazil	284058	69470	1973370

Thailand	237882	58053	1380980
Viet Nam	121500	92880	1128500
Mexico	155713	64523	1004710
Papua New Guinea	216000	43055	930000
United Republic of Tanzania	676821	8526	577099
Total	11864344		61708358

FAOSTAT 2009

All India Final Estimates of area and production of Coconut

States /Union Territories	2007-2008 (Revised)			2008-2009 (Final)		
	AREA ('000 Hectares)	Production (Million nuts)	Productivity (Nuts/ha)	AREA ('000 Hectares)	Production (Million nuts)	Productivity (Nuts/ha)
Andhra Pradesh	101.32	1119.26	11047	104.00	970.00	9327
Assam	19.00	136.00	7158	18.80	147.10	7824
Goa	25.50	127.60	5004	25.61	128.18	5005
Gujarat	16.40	138.30	8433	15.98	157.42	9851
Karnataka	405.00	1635.00	4037	419.00	2176.00	5193
Kerala	818.80	5641.00	6889	787.77	5802.00	7365
Maharashtra	21.00	175.10	8338	21.00	175.10	8338
Nagaland	0.90	0.20	222	0.92	0.55	598
Orissa	51.00	275.80	5408	51.00	275.80	5408
Tamil Nadu	383.37	4968.20	12959	389.60	5365.00	13771
Tripura	5.80	11.40	1966	5.80	11.40	1966
West Bengal	28.60	355.50	12430	28.60	355.50	12430
A & N Islands	21.60	80.60	3731	21.69	82.00	3781
Lakshadweep	2.70	53.00	19630	2.70	53.00	19630
Pondicherry	2.20	26.60	12091	2.10	30.70	14619
All India	1903.19	14743.56	7747	1894.57	15729.75	8303

Source: Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India.

Kerala stands first in India in area and production of coconut while productivity is highest in Andhra Pradesh.

Productivity is the highest (2962 nuts per ha) from Maharashtra as per 1995-96 figures reported by Hand Book of Horticulture PP -647)

Major problems of Coconut production in India

During recent years, there is decline in trend of area and production of coconut in Kerala. This may be attributed to

1. Root wilt disease in coconut and = Mainly in South Kerala
2. Fluctuation in prices of coconut.

Due to sudden rise in prices of natural rubber during seventies, many farmers preferred large scale planting of rubber replacing standing crop of coconut.

Mite Problem during recent years.

Composition and uses of coconut

1) Nut :

- 1) Coconut water – increases blood circulation in kidneys , i.e., diuretic and eliminates mineral poisoning.
- 2) Kernel
- 3) Shell
- 4) Husk

2) Coconut water

- 1) Diuretic
- 2) Increases blood circulation in kidneys
- 3) Eliminates mineral poisoning
- 4) Good substitute for saline glucose under conditions of gastroenteritis.

Nata De cocoa: A product from coconut water developed from National Institute of Science and Technology, Philippines. It is a delicious food article of Philippines and introduced into local market or Kerala i.e., “Coconut salad” with better consumer acceptability. It is prepared from coconut water by mixing sugar, acetic acid and a culture liquor.

Nata de cocoa is a product of coconut – after hardening and making block like.

3) Kernel/ meat

- 1) Fresh form is used in
 - Culinary preparations.

➤ Composition of fresh coconut

- Water = 45 per cent
- Protein = 04 per cent
- Fat = 37 per cent
- Minerals = 4 per cent
- Carbohydrate = 10 per cent

4) Copra: Dried kernel. Richest source of vegetable fat containing 60 to 67 per cent oil
In Kerala 60 to 65 per cent of the total coconut produced is converted in to milling copra.

There are two types of copra i.e.,

1) Ball copra =Whole = It is prepared by storing fully mature nuts (unhusked) for 8 to 12 months.

2) Cup copra= split into two halves = Cup copra is used for house hold purpose in North India, since fresh nuts are not available for edible purpose.

Coconuts are chief source of vegetable fats. Vegetable fats are solid or semi solid at ordinary temperature.

Oil = 60 to 67 per cent

Lauric oil : Coconut oil is referred as lauric oil in world market due to high proportion of lauric acid in it which is not present in other vegetable oils.

Oil cake = 30 to 40 per cent which is used as cattle feed and poultry feed.

Virgin coconut oil

It is also made from the milk extracted from raw kernel. This is done on a small scale by the traditional method which is now partially mechanised or on a large scale by adopting wet processing technology. Coconut milk is fermented and then by mechanical process, water is separated from oil. No heating or application of sunlight or dryer is done for the process.

Desiccated coconut (DC), Coconut Cream, Coconut Milk, Virgin Coconut Oil and Spray Dried Coconut Milk Powder are the convenience coconut products manufactured in the country. Desiccated coconut is used as a substitute to grated raw coconut in various food preparations. Desiccated coconut is marketed in bulk as well as in small packs. Defatted desiccated coconut is also available in the country.

Oil cake

Coconut cake is the residue left after the extraction of oil from copra which is mainly used as a cattle feed. Coconut cake contains 4-5 per cent oil which is extracted by solvent extraction

process. This oil is generally used for industrial purpose and de-oiled cake is used to make mixed cattle feed

Coir Pith

Coir pith a waste product obtained during the extraction of coir fibre from husk is very light, highly compressible and highly hygroscopic. It is used as a soil conditioner, surface mulch/ rooting medium and desiccant. Composted coir pith is an excellent organic manure for indoor plants as well as for horticulture crops. Several firms are manufacturing composted coir pith in the country. Compressed coir pith in the form of briquettes for easy transportation is also manufactured in the country.

Coconut Shell based Products

Shell charcoal, shell based activated carbon, shell powder, shell handicrafts, shell ice cream cups and bear glasses, ladles, forks, show pieces, shell buttons, etc. are the shell based products available in the country.

5) Husk

Husk, forms the basic raw material for coir industry. It employs over half a million people and earns foreign exchange.

Stage of nut maturity for best quality coir = 10th month stage

Husk in coconut is about 30 to 45 per cent of nut weight on ripening.

In the husk about 30 per is fibre and 70 per cent is coir dust.

World coir production = 0.30 million tones of which 50 per cent is from India alone.

Rubberized coir industry

- Mattresses (Gadi)
- Pillows
- Cushions
- Folding car seats etc

6) Toddy: Sugar containing juice, called toddy is collected on tapping un opened spadix i.e., before the flowers fully develop (Sap of the coconut palm). Sweet toddy is the unfermented fresh juice obtained by tapping. Toddy on fermentation becomes an alcoholic drink.

Coconut leaves are plaited and used for thatching houses and sheds in rural areas.

It is also used for thatching 'honeymoon huts' and such huts in town and cities.

Plaiting of coconut leaves is a cottage industry in traditional coconut growing states. Midribs of leaves are used to make brooms of different types which are used for cleaning rough grounds and floors.

Brooms of midribs of coconut leaves are manufactured on a commercial scale in Tamil Nadu and Karnataka.

Climate and Soil for coconut

Climate

Tropical palm :Coconut is a tropical palm preferring humid tropical climate. However, coconut is highly adaptable and performs well under a wide range of environmental conditions of climate, altitude and soil.

Best yields from coconut plantations are realized under the following conditions;

1) **Latitude:** Ninety per cent of coconut in the world is grown between 20° N and 20 ° S from equator. Near the equator coconut is grown at higher elevation while at higher latitudes in plains.

2) **Altitude:** Generally upto 600m. Can be grown at higher elevation (1000 m.) at higher elevations if near equator.

3) **Temperature:** = 27 to 32 ° C , Mean annual temperature of 27 ° C with a diurnal (hagalina or pratidinada) variations of 6 to 7 °C is ideal.(Hence, in North India we cant grow coconut profitably)

4) **Rainfall:** 1,800 to 2,500 mm per year, well distributed

5) **A sunloving palm :** Insolation/sunlight: Coconut being a sun loving palm requires plenty of sunlight and does not come up well under shade.

Requirement of sun light hours : It requires 7.1hrs. of sunshine per day;; 2000 hrs or more per year.

Palms under shade will be lean, lanky and unproductive.

6) **Humidity:** Coconut likes tropical humid climate and 80 to 90 per cent relative humidity (RH) is ideal. RH below 60 per cent affects the growth. At a RH of less than 50 per cent opening of stomata will be affected.

Soils for coconut cultivation

Soil for coconut: Soils of coconut growing areas range between littoral sands to the heaviest clays.

Ideal soils for better growth should be

- 1) Well drained
- 2) Deep: At least 1 to 1.5 m deep,
- 3) PH = 5.20 to 8
- 4) Rich in organic matter with good water holding capacity,

Cultivars and hybrids in coconut

The major classification of coconut based on stature or height is as follows:

- 1) Tall palms and 2) Dwarf palms: These palms are differentiated as under;

Table: Features differentiating between Talls and Dwarfs in coconut

Sl No.	Characters/Features	Talls (C. nucifera var typica)	Dwarfs(C. nucifera var Nana)
1	Size /stature of the tree (Tree ht. M.)	15-18 m with 25 – 30 fronds	5-7 m with 22 – 28 fronds
2	Age at first bearing/Bearing tendency	Late bearing (7-10 years)	Early bearing (3-4 years)
3	Stem girth (cm)	More (66cm)	51 to 53 cm
4	Leaf length x width (m) (Leaf size)	Longer (3.8 x 2.7)	2.9 – 3.1 x 1.5 – 1.8
5	Length of petiole(m)	Longer (1.3)	0.9 to 1.2
6	Type of pollination	Mostly cross	Mostly self and hence true to type.
7	Size of nut (girth in cm)	Bigger (56)	Smaller (34 -38)

8	Copra content (g)	High (170g)	Lesser (92-99g)
9	Oil per cent in copra	Higher >70%	Lesser (66-70%)
10	Quality of copra, oil and fibre	Superior	Comparatively poor
11	Trunk characters i.e., Bole/sweelling at base	Has swelling at the base	Thin, narrow, linear trunk from ground level
12	Yield per palm	Less (66)	More(66-91)
13	Life span	60-80 years	40-50 years
14	Management requirement	Average i.e., Are adopted to adverse soil and climatic conditions	Better management as it is comparatively less tolerant to drought.
15	Days for germination	95 days	49-61

KAPPADAM: Confined to Trichur District of Kerala. It has large sized nut.

Average weight of copra : 285 g where as it is only 165 g in LO.

Long pre bearing period of 10 years as against 6 to 8 years in WCT.

LAGUNA : Tall type grown in Phillippines

SAN RAMON : commercial type grown in Phillippines.

MACAPUNO : It is grown in Phillippines characterized by the jelly like endosperm inside cavity . Entire cavity of some nuts are filled with jelly like endosperm which is a delicacy in Phillippines. One or two nuts of this kind may be found in a bunch of 5 to 7 nuts while, remaining are ordinary coconuts (6 to 7 % of nuts).

SPICATA : Tall variety of coconut having unbranched inflorescence or rarely with one or two spikelets. The inflorescence usually carries only female flowers with maleness least expressed.

Sl. No.	Cultivar/Hybrid	Parentage	Nut yield/	Copra	Important
---------	-----------------	-----------	------------	-------	-----------

			palm/yr (No.)	content (g/nut)	features
A. TALLS					
1	West Coast Tall (WCT)	----	80	176	Economic life of 75 years. It is a regular bearer producing about 12 inflorescences per year.
2.	East Coast Tall (ECT)	----	73	125	Cultivar grown in east coast of India
3	Lakshadweep Ordinary (Chandra Kalpa)	Indigenous to Laksadweep Island	100	160	Released in 1985 by CPCRI for large scale cultivation in Karnataka, Kerala and AP. Good for toddy tapping
4	Lakshadweep Micro (LM)	-----	160	90	Small sized nuts,
5	Andaman Ordinary (VPM-3)	-----	70-100	186	good toddy yielder.
6	Tiptur Tall	-----	86	178	Popular tall cultivar of Karnataka resembling WCT in most

					of the morphological characters
7	Spicata		116	176	No spike in the inflorescence
8	Benaulim Tall (Pratap)	-----	150	152	Popular cultivar in Goa, Konkan and Coastal Maharastra
9	Phillippines Ordinary (Kerachandra)				For Coastal Maharastra, AP and West Bengal

II Dwarf Varieties: These are shorter in stature and life span as compared to tall. They start flowering in 3-4 years, grow rapidly and bear heavily but have a tendency of irregular bearing . Size of copra and quality is inferior to tall.

Eg: Choughat Dwarf Orange (it is superior to dwarf green in yield and quality) , choughat Dwarf green, Malayan Dwarf yellow, Malayan Dwarf Green, Malayan Dwarf Orange and Gangabondam (grown popularly in AP), Coconino (grown in phillippines for good quality toddy production)

Dwarfs are usually grown for

- 1.** tender nut production
- 2.** Hybrid production and
- 3.** for ornamental value

Table : Dwarf type of coconuts

Sl. No.	Cultivar/Hybrid	Parentage	Nut yield/ palm/yr (No.)	Copra content (g/nut)	Important features
B. Dwarfs					
1	Chowghat Dwarf Orange (COD)	----	63	158	Also a ornamental palm
2.	Chowghat Dwarf Green (CDG)	-----	77	60	For tender nut and ornamental use
3	Malayan Dwarf Yellow)MDY)	-----	66	140	Introduction from Malaysia
4	Ganga Bondam(GB)	-----	68	150	Popular variety in AP
5	Gudanjali Dwarf	-	-	-	Gujarat
6					

Other Dwarf types includes Mangipod (Phillippines), Nuleka (Fiji), Rath Thembli (Known as king coconut in Sri Lanka).

Dwarfs adopted to Indian conditions are of two types

- 1) Javanica : Bearing in 4 years- vigorous and are self or cross pollinated.
- 2) Nana : Bearing in 3 years and self pollinating and are delicate.

<http://www.cpcri.gov.in/farmer.htm>

Table : Coconut varieties released through selection;

Sl. No.	Cultivar	Released under the name	State for which recommended
1	Laccadive Ordinary	Chandrakalpa	A.P., TN, Karnataka, Maharashtra, and Kerala
2	Banawali Green Round	Pratap	Coastal Maharashtra
3	Philippines Ordinary	Kerachandra	Coastal Maharashtra, Coastal AP and WB.
4	Andaman Ordinary	VPM-3	

Hybrids: The manifestation of heterosis or hybrid vigour in coconut was first reported from India in 1937. The inter varietal hybrids produced for commercial plantings are T x D and D x T with different parental combinations. These hybrids are gaining popularity because of their early bearing and high productivity. The plants are dwarf in stature and start yielding from 3-4 years after planting.

Eg: Lakshaganga, Ananda Ganga, Chandra Laksha, Keraganga, Kerasree, VHC-1, VHC-2, etc.

Sl. No.	Hybrid	Parentage	Nut yield/ palm/yr (No.)	Copra content (g/nut)	Important features
C. Hybrids					
1	Chandra Shankara (1985)	COD x WCT	116 (even upto 222 nuts)	215	Released from CPCRI Kasaragod in 1985 for cultivation in Kerala
2.	Chandra Laksha	LO x COD	109 (even	195	----do----

	(1985)		upto 171 nuts)		
3	Laksha Ganga (1987)	LO x GB	108 (even upto 186 nuts)	195	Released by KAU for Kerala, Oil content 70 %
4	Veppankulam Hybrid coconut-1 (VHC-1) (1982)	ECT x DG	98	135	Released from TNAU for TN
5	Veppankulam Hybrid coconut-2 (VHC-2) (1988)	ECTxMYD	107	152	---do---
6	Kera Shankara(1991)	WCTx COD	108	187	Released by CPCRI
7	Ananda Ganga(1988)	AOxGB	95	216	Released by KAU for Kerala
8	KeraGanga(1988)	WCT x GB	100	201	For Kerala
9	Kera Sree(1992)	WCT x MYD	130	216	For Kerala
10	Godavary Ganga(1991)	ECT x GB	140	150	For AndraPradesh(APAU)
11	Kera Sowbhagya(1993)	WCT x SSAT (Strait Settlement Apricot Tall)	116	196	Kerala
12	VHC-3	ECT x MOD			

NCD's in coconut

(Naturally Crossed Dwarfs)

D x T = produced by controlled pollination (i.e., from known talls)

NCDs = From open pollination

Seed plantation for NCD production at

- Kidu, Nettana – 574230, Puttur, Karnataka
- Aralam, Kerala

Question Bank

- 1) Origin of coconut is from _____ (Malaysia or Indonesia)
- 2) _____ state stands first in coconut area (Kerala)
- 3) Coconut is a shade loving plant – True or False (False)
- 4) Mention the differentiating features between Tall and Dwarf cultivars of coconut. ?
- 5) Mention two commercially recommended varieties of tender coconut ? (COD and GangaBondam)
- 6) Mention the list of released coconut hybrids ?
- 7) What do you mean by NCD's in coconut ?

ESTABLISHMENT OF COCONUT PLANTATION

1) SELECTION OF SITE:

Avoid

- 1) Low lying areas subject to water stagnation,
- 2) Shallow soils with underlying hard rock i.e., At least 1 to 1.50 m deep
- 3) Clayey soils: Can be reclaimed by heaping alternate layers of sand and clay.
- 4) Shady situations is avoided

2) PLANTING MATERIALS: Coconut is a cross pollinated palm and selection at various stages is very important to eliminate poor quality seed nuts and seedlings. Coconut being perennial, the performance of palm can be judged only after 15 years of planting.

Poor seedlings will cause considerable loss of

1. Time: i.e., economic lag and
2. Money to the grower

Selection of Mother palm, Seed nuts and seedlings in coconut

A. Selection of Seed Plantation

In every coconut growing country certain areas of reputation in coconut production like Arasikere and Tiptur in Karnataka are identified as Centres of Coconut mother palm selection. The selected plantation should be

- 1) Having high proportion of heavy bearing palms,
- 2) Free from major pest and diseases
- 3) Avoid small plantation maintained under very favorable conditions as we can not assess the inherent yield potential. Avoid palms located near the cattle shed and compost pits.

B) SELECTION OF MOTHER PALMS

Adequate care should be taken while selecting mother palms in coconut as to avoid palms of low genetic potential. Take care to select mother palms based on the following features in a reputed coconut seed plantation.

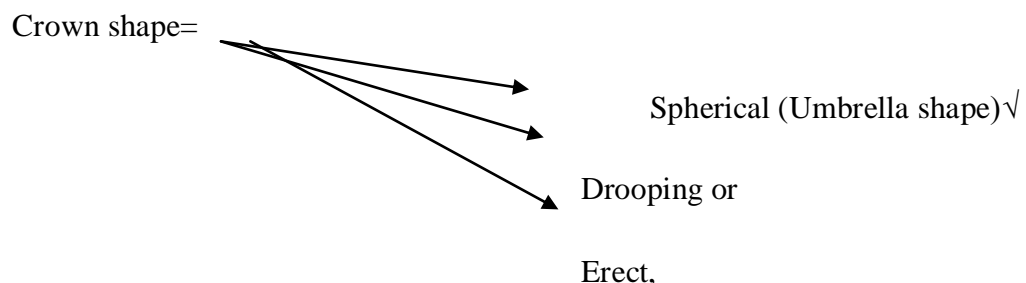
- 1. Age of the palms:** It should attain a age of at least 20 years and not above 60 years of age. Select palms which have attained full bearing stage and have been giving regularly high yields for atleast four years (if it is from unknown parentage). However, seed nuts can be collected from newly established seed gardens irrespective of its age as it comes form the progeny of known parentage.
- 2. Yield: Selected palms should be a regular high yielder yielding**

☞ not less than 100 nuts per palm per year

☞ Not less than 150 g copra content per nut (Nut weight = 1.20 kg unhusked and 0.60 kg husked)

Yielding potential can be assessed by counting number of nuts on the crown.

- 3. Shape of the crown (Nature and disposition of leaves on the crown):**In coconut total number of fronds on the crown should be more than 30 and generally crown shape is



✓ = In coconut we have to select spherical froned palms as there is a positive correlation with yield.

A mother palm should have at least 30 fully opened leaves having leaf orientation in all directions i.e., umbrella shaped fronds. Long and thin petioles are not desirable because they are liable to be weak and may easily bend or break under pressure. Hence select palms with strong petiole with wide leaf base firmly attached to the stem. Leaf petiole should

provide adequate support to the developing bunches there by minimizing the possibility of buckling of the bunch stalk and shedding of nuts in the immature stages.

- 4. Nature, Number and sequence of production of inflorescence:** Every leaf axil should have one inflorescence with large number of spikes (30 to 35 spikes per inflorescence) and one or two female flowers per spike.

Bunch stalk should be sort, stout and strong and should not show any tendency to droop down and buckle. Palms having thin, long and pendulous inflorescence stalks are undesirable. At any time there should be 12 bunches with nuts at different stages of development.

- 5. Size and shape of nuts:** Fully dried unhusked nuts should weigh more than 1.20 kg and husked nut should be more than 600 g and copra content of 150 g and above. Nuts of round and oblong shape are better if selected. Palms producing barren nuts or those shedding large number of immature nuts should be discarded.

C) SELECTION OF SEED NUTS

Nuts with irregular shape and size and improper development should be avoided.

1) Season of nut collection :

In India female production is high during March to May and low in September to January.

Season of nut collection under West Coast : From selected palms seed nuts can be collected during the period from January to April and sown in June in the West coast region as nuts are generally bigger and give better germination. In east coast region nuts are sown during October- November. Season of seed nut collection may have to be adjusted to suit local conditions so that, the seed nuts can be sown in the nursery after about two months of storage.

2) Maturity of nuts: The seednuts takes about 12 months for its full maturity. Mature nuts can be identified on the basis of the following characteristics.

- 1) Resonant or ringing sound on tapping: Mature nuts will produce a resonant and ringing sound on tapping which can be identified by experience. Immature nuts will produce dull sound.

- 2) Browning of inner fibers: There will be dry husk with distinct browning of the inner fibers in case of fully mature nuts.
- 3) Free movement of water with in nuts and reduction in wieght
- 4) Light in weight : reduction in weight.

3) Storage of seed nuts : Minimum for 2 months under shade .Nuts are unfit for sowing if entire water is lost during storage. Seed nuts should be stored for a minimum period of two months under shade. It is also advisable to sprinkle water over the stored nuts in order to minimize drying nut water during storage.

D) SELECTION OF SEEDLINGS:

- 1) **Early germination:** Under favourable environmental conditions and proper management coconut will germinate in
Germination period: Normally 2 to 3 months (8 to 10 weeks (i.e., 2 to 3 months while arecanut in 2(53 days) to 3(94 days) months.)

Reject nuts which germinate late : Reject a coconut seedling, which takes more than five months for germination.

2) Vigourous seedlings: (6 leaves and > 10 cm collar girth) The vigourous seedlings which are one year old, having minimum of six leaves and girth of 10 cm at the collar should be selected. Early splitting of leaves and dark green coloured leaves are desirable character for selection at seedling level.

Recovery of good seedlings will be only 60 to 65 per cent of seed nuts sown.

Coconut is propagated through seedlings raised from selected seednuts. Generally 9 to 12 month old seedlings are used for planting. Select seedlings, which have 6-8 leaves and 10-12 cm collar girth when they are 9-12 month old. Early splitting of leaves is another criteria in the selection of coconut seedling.

Question Bank

- 1) Narrate about mother tree selection in coconut ?
- 2) How do you select coconut seedling from the nursery ?
- 3) Coconut seed nuts are stored for a minimum period of ____ months before sowing in the nursery (two months)
- 4) How do you assess the maturity of nuts in coconut ?
- 5) From fruit setting to maturity coconut takes about ____ months (11 to 12)

METHODS OF SOWING SEED NUTS IN COCONUT

Methods of seednut sowing (Based on the positioning of seednuts)

- ❖ 1) Vertical method:
- ❖ 2) Horizontal method: Stalk end horizontally

Seed nuts are sown in the nursery at a spacing of 30 cm apart (center to center)

Germination period: 3 to 5 month (or two to five months)

A) Vertical method of sowing seed nuts: It is planting with stalk end up and practiced only in India.

Advantages

Easy bundling /packing and transportation of seedlings. I.e., handling becomes easier

Disadvantages

Nut water does not remain in close contact with germinating embryo.

B) Horizontal method: With stalk end of nut placed horizontally. It is the common and recognized method of sowing in other coconut growing countries.

Advantages

Higher percentage of early and total germination, vigorous seedling with thicker girth at the collar, possibly because of nut water is in close contact with embryo.

Disadvantage

There is possibility of damage to the seedlings during transportation.

Raising of nursery

Sow seed nuts in beds of size 1 m width and convenient length at a spacing of 40 cm x 30 cm in either vertically or horizontally in 20 to 25 cm deep trenches.

Poly bag nursery for coconut sowing

Advantages of poly bag nursery over conventional nursery are

1. Reduced transplanting shock due to the absence of root damage.
2. Ease of irrigation and fertilizer application in the bag

3. Early germination :The improved water holding capacity of the potting medium thereby it helps to maintain required moisture for early germination.

Question Bank

- 1) Mention the advantages and disadvantages of vertical method of seed nut sowing in coconut ?
- 2) _____ and _____ are two commonly adopted methods of coconut sowing (Vertical and Horizontal)
- 3) List out the advantages of poly bag nursery over conventional nursery ?
- 4) In coconut it takes about _____ months from sowing to germination (3 to 5)
- 5) Mention the advantages and disadvantages of horizontal method of seed nut sowing in coconut ?

Planting in coconut

TIME OF PLANTING

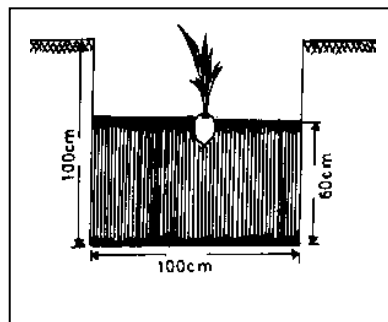
- a) **Well drained soils** : onset of south- west monsoon
- b) If irrigation is available : Better to plant one month before the onset of monsoon, so that seedlings get established before heavy rains.
- c) Low lying areas subject to inundation during monsoon period : After cessation of monsoon (i.e., usually after the heavy rains).

4) PREPARATION OF PITS FOR PLANTING

Stage of seedling at the time of transplanting : 9 to 12 months in India

Note: In certain parts of Karnataka and AP 2 to 3 years old seedlings are transplanted particularly in flooded areas and poorly drained soils. However, it causes poor and delayed establishment.

The depth of pit depends on the type of soil and environmental factors



- a) **Lateritic soil with rocky substratum** : Deeper and wider pits are made. i.e., 1.2 m x 1.2 m x 1.2 m and fill the pits up to 60 cm (50 % depth) before planting with top soil + Cow dung + ash.
Addition of common salt
Apply 2 kg common salt in the laterite soil which helps in loosening the soil.
- b) **Loamy soils with low water table**: Pit size of 1m x 1m x 1m and fill upto 50 per cent of pit.
- c) **In areas with high water table**: Surface or planting on the mounds is followed.

Widen the pits every year before applying manure by slicing down from the edges of the pit.

5) Spacing

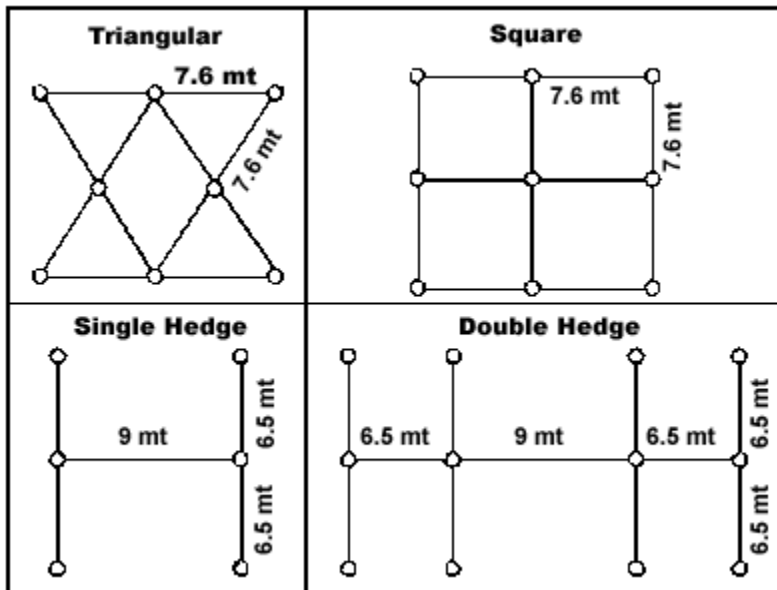
Optimum spacing for coconut : Canopies of neighboring palms should not touch each other between 8 and 12 years of planting.

- 9) Talls → 8 m x 8 m (155 plants per ha) or 8.5 m x 8.5 m (138 plants per ha)
- ii) Dwarfs and hybrids → 7m x 7m or 7.5 m x 7.5 m = (178 palms per ha)
- iii) Planting along the boundary of plantation → 7 m x 7 m (204 palms per ha)

Table : Spacing and system of planting in coconut

Spacing	System of Planting	No. of plants per ha
7.5m x7.5 m	Square	175
8 m x 8 m*	Square	155
7.5 m	Triangular	205
8 m*	Triangular	180
9 m x 6.5 m	Rectangular	170
8.5 m x 6.5 m	Square system	138
9 x 5 m	Single hedge system	For establishment of seed gardens.

* = As practiced by farmers in some places of Karnataka.



MANURING IN COCONUT

Starting from first year onwards we have to manure regularly in coconut for

- Good vegetative growth
- Early flowering and
- High yields

In coconut it takes 32 months from induction of female primordial to flowering. If full dose of fertilizers is applied from 3rd year onwards there will not be button shedding in the initial years of bearing.

Period required for observing response: A minimum period of 3 years is required to observe the response to fertilizer (i.e., flower primordial induction takes place 32 months prior to the emergence of spadix.)

Recommendation of Manures and fertilizers to coconut

Organic manure: 50 kg per palm per year.

Addition of neem cake @ 1 to 5 kg per palm is also beneficial / recommended.

RDF for coconut (4th year onwards) : 500 : 330 : 1200 g NPK per palm per year.

Fertilizers: As per CPCRI, Kasaragod *

Year	May- June			September – October		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
First	---	---	---	50	40	120
Second	50	40	125	110	80	275
Third	110	80	250	220	160	550
Fourth year onwards	170	120	400	330	200	800

I year = I application of fertilizer is done three months after planting (Nearly 1/10 of the recommended dose)

II year = 1/3rd of the recommended dose of an adult palm,

III year = 2/3rd of the recommended dose of an adult palm.

IVth Year and above = Full dose (500 :330:1200 NPK g/palm/year: It works out to nearly 1kg urea, 1.5 kg Mussorie Phos/Rock Phosphate and 2 kg of muriate of potash)

Method of fertilizer application in coconut

9. Premonsoon application

(May – June): Broadcasting : Spread the fertilizers around the palms with in a radius of 1.80 m (6 feet) and forked in.

II. Post monsoon application (September – October): Basin method: Apply fertilizers in circular basins of

Radius = 1.80 m

Depth = 25 cm

Leaving the base of the palm undisturbed.

FYM is spread at the base of the basin over which RDF is spread. It is also better if RDF is applied one or two weeks after the application of FYM.

Since 80 per cent of roots is confined to 2 m radius from the base it is advisable to apply fertilizers with in that limit. Apply green leaf /compost @ 50 kg per palm. Spread organic manures in the pits. Recommended dose of fertilizer is spread in the basin over organic manure and the basins may be covered. Widen the basin /pits every year till 4th year. Widen the basin upto 4th year of planting.

Irrigated plantations: Fertilizers may be applied in four or more equal split doses avoiding heavy rainfall season.

Fertigation : Urea,

Diamonium phosphate (DAP)

Phosphoric acid (Commercial grade) and

Muriate of Potash can be applied in 4 or 6 equal splits through fertigation.

Pocket Manuring

It is a new method of fertilizer application (Based on studies in established coconut plantations of Tamil Nadu) in holes dug with a crow bar at about 25 cm apart in circular basins formed around the base of the palms. After filling the holes of 15 cm deep with fertilizers, they are to be properly closed with sand or soil. Prescribed amount of organics should be incorporated into the basins and irrigated.

Advantages of pocket manuring in coconut

- 1) Easier, cheaper and quicker method. Two people can fertilize 50 trees a day.
- 2) Better absorption of nutrients through roots
- 3) Prevents nutrient loss by way of leaching and run off.
- 4) This method of application suits well in sloppy lands/areas.

Fig : Holes at 25 cm apart and 15 cm deep and close with sand or soil.

Water management in coconut plantations (Irrigation) Though coconut can tolerate dry spell to some extent, long dry spells will adversely affect the growth and productivity of the palms.

Irrigation in Coconut Prolonged dry spell (5 to 6 months or more) results in;

1. Yellowing and drooping of leaves,
2. Wilting of lower whorls,
3. Reduction in yield : due to reduction in number of bunches, female flowers per bunch and setting percentage besides shedding of immature nuts and tender nuts,
4. Immature nut fall and button shedding,
5. Thickening the walls of roots resulting in reduced absorption capacity.
6. Aggravated stem bleeding disease.
7. Increased leaf fall

8. Quality : Reduced nut size and copra content

All these symptoms results in growth stagnation and reduced leaf and flower production and decrease in yield.

Drip irrigation: In water scarce areas, drip irrigation is ideal as it saves water, energy and labour and it is an efficient irrigation method.

Placement of drippers : Three to four drippers at the basin of the palm placed at 1 m distance from the bole of the palm. Three drippers are located at 120 ° around the stem of the palm is optimum, when placed at 1 m distance from the bole of the palm. This system is 50 to 70 per cent efficient (Water use efficiency) than traditional system. Mulching with the husk with convex side up will help in conserving soil moisture. Drip irrigation also advances first yield in coconut by 8 to 12 months.

Note:1) In drip irrigation point of wetting should not be shifted.

2) It is not essential to wet all round the palm as 25 per cent of root zone is capable of absorbing more than 85 per cent of total water requirement of most of the palms.

Water requirement/irrigation requirement for coconut

It depends on method of irrigation, whether/season and climatic conditions apart from soil characters.

Apply 100 per cent of recommended irrigation during summer, 60 per cent during winter and 40 per cent during rainless period of rainy sesason.

- West coast =Basin method= 200 liters per palm per irrigation at four days intervals.
- West coast= Drip irrigation = 32 litres per palm per day (at 66 % of open pan evaporation) = 30 to 40 liters per palm per day
- Ring method = 60 liters per palm per day

Cover cropping in coconut

Growing of green manure / cover crops in situ and its incorporation in to the soil has been recognized as the easiest and the most economic method of augmenting the organic matter content of soil.

Incorporate when soil moisture is adequate :Green manure crops should be incorporated at the correct stage of growth when the soil moisture is sufficient to permit complete

decomposition of the green matter. Grasses particularly in heavy rainfall areas should not be removed during monsoon as they are very good soil binders and solar energy trappers.

It has beneficial effects like

Leguminous cover crops recommended in coconut plantations are

1) *Mimosa invisa*, = Generates 25 kg green manure per palm basin which can be incorporated into the basin before flowering

2) *Stylosanthes gracillis*,

3) *Calopogonium muconoides*,

4) *Macuna bracteata* = A cover crop introduced from Tripura in Kerala. Not flowerin under Vellanikkara conditions.

5) Velvet bean = *Macuna spp.*

Other crops that are grown as green manure cum cover crops in coconut plantations are;

Perennial source of green leaf :*Glyricidia aculate* and *Tephrosia candida* can be grown along the boundaries of the plantation and the green matter is cut and applied to the coconut palms as a perennial source.

Multiple cropping in coconut

Coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the plantation.

Based on the growth habit of the palm and the amount of light transmitted through its canopy, the life span of coconut palm could be divided into three distinct phases from the point of view of intercropping.

9) **Young Plantation Up to 10 years:** From the time of planting till the development of canopy;

In this situation there will be good light transmission initially but decreases with age.

Suggested to go for inter cropping with annuals or biennials.

B) Middle aged palms (9 to 25 years) / Intense shaded situation: Maximum ground coverage (80 %) and canopy at lower height due to shorter trunk, Poor light availability. At this stage it is not suitable to grow other crops in the interspaces of the plantation.

C) Grown up palms (> 25 years): Gradual increase in the magnitude of light penetration to the ground ; and decrease in the apparent coverage of canopy. The trunk will be taller and this situation is ideal for raising annual and or perennial crops.

INTERCROPPING: It refers to the cultivation of annuals or biennials in the interspaces of coconut.

Eg.

1) Tropical Tuber crops like tapioca, elephant foot yam, sweet potato, colocasia, greater yam, lesser yam,

2) Rhizome spice crops: Ginger and turmeric

3) Cereals: Upland rice varieties, Maize, pearl millet, finger millet (*Eleusine corecana*),

4) Vegetable: in maidan areas of Karnataka= Chillies, potato, French beans,

Kasaragod (Coastal tract) conditions = Coccinia, snake gourd, bottle gourd, amaranthus, brinjal, bitter gourd,

5) Pulses =Cowpea, black gram, green gram, red gram, Bengal gram, soya bean, in maidan tracts of Karnataka. Under Kerala conditions it is horse gram, cow pea, green gram, and black gram,

6) Oil seeds : ground nut,

7) Fruit crops: Banana and pine apple. Papaya can also can be intercropped with coconut.

8) Floriculture: Orchids, anthuriums, and other cut flowers and ornamentals can be successfully grown in coconut plantation.

9) Medicinal and aromatic plants: Lemon grass, Kacholam, dioscorea, arrow root, sida, hippali (Long pepper), neela amari, Patcholi (*Pogostemon* ,) adapathiyan,

MIXED CROPPING : Growing of perennial crops in association with coconut palm is referred to as coconut based mixed cropping.

Eg. Cocoa, clove, nutmeg, cinnamon, pepper, betel vine, jack, bread fruit, cardamom, coffee, vanilla and mango.

HIGH DENSITY MULTISPECIES CROPPING SYSTEM (HDMSCS)

High Density Multispecies Cropping System (Hdmscs) involves growing of large number of crops to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash.

HDMSCS is the system where a number of crops are grown in high plant density in unit area of land. This system includes annuals, biennials, and perennials. The HDMSCS model developed involves crops viz., mango, bread fruit, jack, nutmeg, clove, sapota, acid lime, guava, pepper, subabul, banana, pineapple, papaya, coffee, elephant foot yam, cococasia, and cassava (17 crops were included). The annual crops (except banana) were withdrawn from the system in stages as the perennials grow. Some of the perennials like acid lime, sapota, mango, guava, pepper, subabul, papaya and coffee were also removed as their performance was not satisfactory. HDMSCS aims at to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash.

Question Bank

- 1) Mention the size of pit for planting coconut seedlings
- 2) Age of coconut seedlings at the time of transplanting is ----- months (9-12)
- 3) Recommended dose of NPK fertilizer in yielding coconut plantation is -----
g/tree/year (500: 330: 1200)
- 4) Mention the method of fertilizer application in coconut
- 5) List the cover crops for coconut cultivation
- 6) Narrate about multiple cropping in coconut

Plant Protection in coconut

Pests:

- 1) Rhinoceros beetle
- 2) Leaf eating caterpillar Red palm weevil
- 3) Root grubs
- 4) Mites , Eriophid mite Mealy bugs
- 5) Scales
- 6) Coreid bugs
- 7) Rats etc

Diseases:

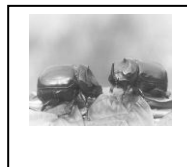
1. Bud rot Stem bleeding
2. Anabe roga
3. Pestalotia leaf spot /Grey leaf spot :
4. Thanjavur wilt / Ganoderma wilt:
5. Root (wilt) disease:
6. Mahali or fruit rot and nut fall:

Other diseases:

- 1) Button shedding,
- 2) Production of barren nuts,
- 3) Root wilt,
- 4) Tatipaka in AP
- 5) Leaf yellowing and
- 6) Tapering or pencil point disease.

PESTS OF COCONUT

1) Rhinoceros beetle: *Oryctes rhinoceros*



It is a most serious pest of coconut,

Stage of damage of insect: Adult beetles which are usually active during night (Nocturnal). The adult beetles have dark brown to black colour and it is characterized by the presence of a horn on the head.

Nature of damage:

- ☞ Boring the soft tissues of the growing bud or cabbage (i.e., unopened fronds and spathes) by cutting and chewing the tender unopened leaves and spathe. It also destroys the inflorescence while chewing leading to direct (Prevents the nut production) and indirect losses.
- ☞ Triangular / Geometric cuts: The attacked fronds when fully opened show characteristic triangular cuts and there will be presence of chewed up material around the hole.
- ☞ Death of palm: The repeated infestation by the beetles leads to the death of palm.

Management / Control

- I. **Sanitation in the plantation:** Sanitation in the plantation has to be maintained by proper disposal of decaying organic debris, Eg: Cattle dung, Compost etc.
- II. **Manure pits and other possible breeding sites are to be treated with carbaryl (10%) @ 350 g / 3 m³ pit (1 m depth, 1 m width and 3m length) . OR** Manure pits and other breeding sites are to be treated with carbaryl 50 WP at 0.01 per cent concentration. Spraying is to be done thrice i.e., During April, September and December.
- III. **Mechanical Removal :** Hook out the beetle from the attacked palms using beetle hook.

As a prophylactic measure, fill up the top most three leaf axils with Sevidol 8G(25g) + fine sand (200g) thrice in April, September and December.

Remove the beetles from the infected fronds with the help of beetle hook and fill up the innermost 2-3 leaf axils with

Malathion + Sand or

Qinolphos + sand In equal proportion (100g each) .

Leaf axil filling is to be done thrice a year i.e during April, September, and December.

Filling leaf axils with 12 g naphthalene balls (approximately three balls) covered with fine sand at 45 days interval is also effective (Ref: Coconut cultivation technology by Coconut Development Board)

Eriophyid Mite (*Aceria guerreronis* K.,)

Eriophid mite has reached epidemic proportion in recent times affecting production and productivity in many districts of

- Kerala,
- TN and
- Karnataka.

Method of damage: Mites feed underneath bracts at the stalk end of nuts which are whitish and soft with fast multiplying cells. Entry of mites will take place when nuts are of 3-4 months stage since younger nuts will have tightly covered bracts in the perianth region without any space for the entry of mites in the soft region of nuts.

Nuts :

- ✓ Sap is sucked from tender meristematic tissues of immature nuts (buttons at 3 to 4 months stage) under perianth lobes resulting in brown lesions. It invariably affects all the nuts of a tree and almost all the trees in a plantation. The mite being small, is carried away by the wind which acts as the agent of dispersal. Because of this reason it has become a difficult task to contain this pest from spreading quickly in a region.
- ✓ Reduction in size and quality of affected nuts: There will be reduced yield of copra with in the nut.
- ✓ Hardening of husk: The fibrous region in these nuts also becomes hard, hence dehusking becomes difficult.

Symptoms:

- 1) Premature nut shedding, when the infestation is severe.
- 2) Size of nut and husk loses quality due to development of warts and splits on them.
- 3) Malformation of nuts

Management / Control of mites.

Twin reasons causing difficulty in mite control : The control of this mite has become a major problem because of Wind dispersal : speedy dispersal by wind and Faster rate of Multiplication : also due to its fast multiplication rate

1) Root feeding : Root feeding of monocrotophos (10 ml in 10 ml water). However, a waiting period of 45 days has to be given before harvest.

2) Spraying : Use of wettable Sulphur (@ 5 g/litre of water) or neemazal @ 5 ml /litre of water, or Monocrotophos (for spray) or Dicofol @ 6 ml per liter of water (Dicofol 20 EC = Kelthane)

Nutrient Management : 5 kg Neem cake per palm + Recommended N and P + 31/2 kg MOP (instead of recommended 2 kg) + 1 kg Gypsum (Gypsum = $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) + 50 g Borax per palm per year.

Question bank

1. List out the important pest and diseases in coconut
2. List out the disorders in coconut
3. Mention the symptoms of Rhinoceros beetle damage in coconut
4. Mention the symptoms of damage and management of Eriyophid mite in coconut
5. Eryiophid mite incidence is severe during ----- season (summer)

MAMMALIAN PESTS

1) Rats:

Rodents damage tender nuts by making entry hole and feed on internal contents and cause severe crop loss. Droppens nuts will have characteristic holes at the base.

Management / Control of Rats :

For the control of rats food and shelter should be avoided. Rat control by the use of poisonous chemicals is dangerous to human being (as rat is a mammalian pest)

Provide mechanical barrier: GI sheet bands of 40 cm wide, fixed around the trunk of palms at a height of 2 m from the ground.

3) Poison baits:

1) Single dose acute poisons Eg. Zinc phosphide

2) Multiple dose antiblood coagulants: Eg. Warfarin, Fumarin compounds. Eg : Roban – Avoids blood clotting in rats and there will be continuous bleeding leading to the death of rats.

3) Fumigate the hiding places using Aluminium phosphide tablets. :Rat burrows in the fields (in rice ecosystem etc.,) can be fumigated with aluminium phosphide tablets).

Disease of coconut:

Diseases:

- 1 Bud rot
- 2 Stem bleeding
- 3 Anabe roga
- 4 Pestalotia leaf spot /Grey leaf spot :
- 5 Thanjavur wilt / Ganoderma wilt:
- 6 Root (wilt) disease:
- 7 Mahali or fruit rot and nut fall:

Disorders in coconut:

- 8 Button shedding,
- 9 Production of barren nuts,

- 10 Root wilt,
- 11 Tatipaka in AP
- 12 Leaf yellowing and
- 13 Tapering or pencil point disease.

Diseases

1) Bud rot in coconut:

Cause : *Phytophthora palmivora* , *P. Katsurae*

This disease is seen in all coconut growing states of India.

Season : Rampant (Aggressive/Higher/Unchecked) during monsoon when temperature is low and RH is high.

Symptoms:

- ❖ Yellowing: Yellowing of one or two younger leaves surrounding the spindle→ Black spots appears on spindle leaves →The spindle wilts and droops down.
- ❖ Rotting : The tender leaf base and soft tissues of the crown rot into a slimy mass of decayed material emitting fowl smell.
- ❖ Fatal : The disease kills the palm if not checked in early stages. Ultimately the entire crown falls down and the palm dies.

Management/Control of bud rot in coconut:

1)Prophylactic spray: As a prophylactic measure, spray 1 per cent Bordeaux mixture on spindle leaves and crown of affected palms as well as neighbouring palms before the onset of monsoon. Spraying : Spray with 1% Bordeaux mixture during May and September if the disease occur frequently.

2)Application of Bordeaux Paste : If noticed in early stages, apply Bordeaux paste on the crown after thorough cleaning. (Bordopaste =BM 10% = 100 g CuSO₄ +100 g Lime in one litre water). Neighboring trees should be sprayed with BM (1%) as a prophylactic measure.

3) Burn all disease affected tissues removed from the palm.

Button shedding:

It is usual phenomenon to notice dropping of nuts in their very initial stages of maturity (3 to 4 months stage). It is the natural phenomenon exhibited by plant to protect itself from exhaustion.

Reasons and Remedies for button shedding in coconut.

1) Nutritional Imbalance / deficiencies: NPK recommended for coconut is 500 : 330 : 1200 g per palm per year. Usually full dose of NPK is applied from 4th year onwards.

Application of K and N minimized the incidence of button shedding in coconut.

2) Unfavorable conditions :

a) Moisture: Deficiency / stress or water logging / excess of water promote button shedding

b) Hard pan: A rocky strata at shallow (< 1.5 m) depth.

3) Pathogen and insect: Some pathogens especially fungi are known to be associated with the button shedding. They include

Colletotrichum spp,

Phytophthora spp.,

Botrydiploidia spp.,

Cause premature nut drop in coconut.

Barren Nut

Insects viz., 1) Coried bug (The attacked buttons do not develop resulting in immature nut fall.) The nuts if developed may become barren.

2) Eriophid mites and

3) Rodents problems (Attack tender nuts resulting in immature nut fall.) are also results in nut drop.

4) Defective pollination and fertilization: Many of the talls are cross pollinated. There may be inadequate pollination possibly due to high temperature or hot winds which cause desiccation or drying of the stigmatic surface. For this we can;

a) Keep bee hives

b) Spray 2,4-D @ 60 PPM to improve fruit set and yield.

5) Inherent capacity / Genetic make up (inborn nature) of the palm : We can resort to selective felling and replanting.

Harvest and yield in coconut:

Pre bearing age in coconut : Tall : 6 to 7 years

Dwarfs : 3 to 4 years

Hybrids : 4 to 5 years.

Longevity of the palm : Talls = 70-80 years, and

Dwarfs = 40 - 50 years.

Stage of harvesting :

a) For getting copra fully matured nuts (Ripen nuts) are harvested.

b) For tender nut purpose : 6 to 7th months stage

Frequency of harvesting coconuts: Once in a month (In well maintained and high yielding plantations bunches are produced regularly and harvesting is done once in a month.) It varies depending upon the yield of the palms.

Number of harvests per year : Usually nuts are harvested 6 to 10 times in a year.

Season of harvesting: Year round harvesting. Inflorescence is produced in every leaf axil (12 to 14 leaves per year) leading to year round harvesting. However, main harvesting season is Summer.

required stage of ripeness in Indonesia, Malaysia and other South East Asian countries.

Yield: 80 to 100 nuts per palm per year. (National average yield is 44 nuts per palm per year)

Hybrids: 100 to 130 nuts per palm per year,

Storage and seasoning of harvested nuts:

Harvested nuts are stored or seasoned before further processing. This practice has the following advantages:

- 1.** Decrease in moisture content,
- 2.** Increase in thickness of copra,

3. Increase in oil content,
4. Greater meat resistance to bacterial sliming while sun drying,
5. Easier husking,
6. Cleaner and easier shelling,
7. Uniform quality of copra,

Post harvest processing

In the traditional coconut producing States of India, the post harvest processing is presently confined to the production of edible and milling quality copra, coconut oil and coir and coir based products.

Copra processing

Optimum moisture content in copra is 5 to 6 per cent. Sun drying, smoke drying, kiln drying and indirect hot air drying are the commonly used methods for drying coconut.

Copra grading

The copra is graded in the order of its market value. The grading is mainly based on moisture content, the foreign matter and black copra.

Moisture : 6 per cent

Oil content : 71 per cent

Acid value : 2.5 per cent

Foreign matter : 0.5 per cent

Mouldy cups : 5 per cent

Wrinkled cup : 5 per cent (free)

Black copra : 1 per cent (free)

Coconut Value Addition

Tender coconut water

Tender coconuts are valued both for the refreshing drink and gelatinous kernel, which is a delicious food. The composition of tender nut water from this variety is as follows

Quantity of tender nut water : 350 ml/nut

Calorific value : 17.5/1000g of tender nut water

Sugar : 7.1 mg/100 ml of tender nut water

Potassium : 2000 ppm

Sodium : 20 ppm

Snow Ball Tender Nut (SBTN)

Snow ball tender nut is a tender coconut without husk, shell and testa which is ball shaped and white in colour.

Coconut of eight months age is more suitable for making SBTN in which there is no decrease in quantity of tender nut water and the kernel is sufficiently soft.

Coconut chips

Fresh kernel of matured coconut can be used for preparing coconut chips. This can be prepared from mature coconut kernel after removing the moisture content of the kernel partially by osmotic dehydration by using various osmotic media. The dehydrated coconut chips are in ready-to-eat form and can be used as snacks. It could also be used at any time just like fresh kernel after dehydration of the chips.

Virgin Coconut Oil

VCO produced from coconut milk cream by hot process took less boiling time and also the produced byproduct skim milk can be used as nutritious beverage containing protein and micronutrients. Fermentation time could be reduced by adding starter culture to the coconut milk for the production of VCO.

Husk

About 30 per cent of husk is fibre and 70 per cent is coir dust. Coir and coir products form the major output from coconut husk. Coir pith is useful as a manure (after composting), mulch material and for making briquettes. The coir pith briquettes can be used as a substitute fuel in the place of firewood for tile and brick industries.

Coconut shell charcoal

It is used extensively for the manufacture of activated carbon. The charcoal has a high absorption capacity for gases and colouring matter and can be used as a refining agent, both as deodorizer and a decolouriser.

Activated carbon

Shell charcoal on activation is transformed into activated carbon which is having the ability to absorb effectively even trace quantities of either unwanted or valuable liquids and gases. Activated carbon is used in solvent recovery processes, water and effluent treatment and the treatment of flue gas before discharge into the atmosphere.

Shell flour

Shell flour is prepared by grinding clean coconut shells to a fine powder. It is used as a filler in the manufacture of phenolic moulding powders. It is also used as a filler in phenolic glues for plywood and laminated sheet manufacture, filler for mosquito incense coils and filler in specialized surface finishes, resin castings etc.

Handicrafts from coconut

A variety of handicraft items, from utility articles to show pieces are manufactured from coconut materials such as wood, shell, fibre and leaflet midrib. Coconut shell is hard, takes a high polish, can be carved, coated with lacquer, inlaid with silver or other metals and generally used with ornamental effect.

Coconut wood

Freshly cut coconut trunks from senile coconut trees can be used as timber after treatment with preservatives for increased shelf life. Treated coconut timber can be used as electric poles, telecom poles and for interior uses for making furniture, window and door frames.

Question bank

1. Write about value addition in coconut
2. Write about the management of button shedding in coconut
3. What are the advantages of storage of harvested nuts?
4. Pre bearing age in tall coconut varieties is -----years (6-7)
5. Tender nut purpose the nuts are harvested at ----- months stage of maturity (6-7)

LECTURE 15

Palmyra (*Borassus flabellifer* L.) $2n = 36$,

Family : Palmae

It is recognized as the state tree of Tamil Nadu in 1978, recognizing its importance. It has been estimated that there are about 8.6 crores of Palmyra palms existing in India of which 5.02 crores of palms are alone spread over Tamil Nadu and remaining 3.58 crores palms are in Andhra Pradesh.

Research work on palmyra palm in India

1) Palmyra research Station at Srivaliputhur, Tamil Nadu (TNAU)

AICRP on palmyra

a) at Padiramamudi (AP)

at Killikulam, PIN – 628 252, Tamil Nadu (TNAU)

Kalpagathara (Tree of life) or Kalpaghataru or Kalpakavirucham

All the parts of the palm are useful and over 800 various uses are reported and hence this palm is known as kalpagathara.

Since every part of this palm is utilized it is known as kalpakavirucham.

Edible products of palmyra : Neera, Toddy, Sugar, Jaggary, Candy, Vinegar etc

Commercial products of palmyra : Wood, leaves, roots, Fibre, fruit pulp, fruit fibre etc.

It is a source of food,

Neera or padaneer is a transparent and sweet drink having pleasant smell.

Composition:

Sugar – 12- 16 per cent,

Vitamin c (Ascorbic acid),

Vitamin B (B- complex) and essential amino acids.

Neera is drunk as such or used for preparation of secondary products.

It includes;

Toddy : Due to fermentation of neera (sugary sap) by yeast and bacteria. It contains 5 per cent alcohol.

LECTURE 15

Jaggary : By concentration of neera through gradual boiling. The jaggary is sweet, delicious and superior to cane jaggary.

Palm sugar : Crystallized sap juice obtained by boiling and clarifying,

Palm cola : Aerated soft drink containing palm sugar (11 %), Citric acid, cola concentrate and food colours along with other ingredients.

Palm candy : Directly produced from the sap. It is boiled only to 107 to 108 ° C === Poured in to pots , which is covered and buried under ground for some months == Crystalline sugar candy forms. It has medicinal properties and used against cough and pulmonary infection.

Jaggary : Jaggary of palmyra is sweet, delicious and superior to cane jaggary. Palmyra palm jaggery (gur) is much more nutritious than crude cane sugar, containing 1.04% protein, 0.19% fat, 76.86% sucrose, 1.66% glucose, 3.15% total minerals, 0.861 % calcium, 0.052% phosphorus; also 11.01 mg iron per 100 g and 0.767 mg of copper per 100 g. The fresh sap is reportedly a good source of vitamin B complex.

sugar,

vinegar,

palm-wine,

Medicine : Briefly, the young plant is said to relieve biliousness, dysentery, and gonorrhoea. Young roots are diuretic and anthelmintic, and a decoction is given in certain respiratory diseases.

Sap from the flower stalk is prized as a tonic, diuretic, stimulant, laxative and anti phlegmatic and amebicide. Sugar made from this sap is said to counteract poisoning, and it is prescribed in liver disorders.

and wood. The black timber is hard, heavy, and durable and is highly valued for construction.

Leaves are used for thatching, umbrellas, fans, diaper (napkin/ small towel) articles, hats etc and their

Palmyra fibres : for baskets, brushes, and brooms : Palmyra fibers has a great export potential and is exported to over 30 countries. The stalks are used to make fences and also produce a strong, wiry fiber suitable for cordage and brushes

Seedlings

The peeled seedlings are eaten fresh or sun-dried, raw, or cooked in various ways. They also yield starch, which is locally made into gruel, with rice, herbs, chili peppers, fish, or other ingredients added. It has been proposed for commercial starch production.

Palmyrah roots : Three months old roots (tubers) are edible on cooking

LECTURE 15

Besides neera or padaneer we also get

Fruits/ Nungu, : It weighs 27 to 54 g.

Nungu = Mlayalam, and Talsans = Bengali.

It is tender palmyra fruit. It is delicious and rich in carbohydrate,

Phosphorous,

Iron and

Vitamin –C, Niacin, Riboflavin etc.,

Origin

Palmyra is believed to be a native of tropical Africa, native to tropical regions of Africa, Asia and New Guinea.

Distribution:

World : Assia, Africa and Austrelian continents. is commonly cultivated in India, Southeast Asia, Malaysia

India, Sri Lanka, Mymnar, Bangladesh, Thailand, Vietnam, Malaysia, and Indonesia.

India : Tamil Nadu, AP, Karnatak, Kerala, MP, Orissa, WB, Bihar etc,

Tamil Nadu,: In TN 5.02crore palms out of 8.06 crore palms (Accounting to 58 per cent). In Tirelveli District it is widely distributed.

It has been estimated that there are about 8.6 crores of Palmyra palms existing in India of which 5.02 crores of palms are alone spread over Tamil Nadu and remaining 3.58 crores palms are in Andra Pradesh. Tamil Nadu alone contains about 60 per cent of total palms, signifying its importance Government of Tamil Nadu recognized it as state tree of Tamil Nadu since 1978.

Andra Pradesh : 3.58/ 8.60 crore palms are located.

Botany: Palmyra (Borassus flabellifer L.) belongs to family palmae,

It is a dioecious (rarely hermaphrodite) palm where in male flowers are embedded in fingers where as female flowers are sessile.

Species

Borassus aethiopicum - African Palmyra Palm (tropical Africa)

LECTURE 15

Borassus flabellifer -Asian Palmyra Palm (southern Asia)

Borassus heineanus- New Guinea Palmyra Palm (New Guinea)

Borassus madagascariensis - Madagascar Palmyra Palm (Madagascar)

Borassus sambiranensis - Sambirano Palmyra Palm (Madagascar)

Fruit: It is botanically drupe contains three seeds and are 40 - 50 in a bunch.

The palm produces fruits when it attains 15-20 years, giving an annual crop of 50 –200 fruits in 6 – 12 bunches per tree. When the fruits are tender the seeds contain a soft, sweet, jelly like endosperm called nongu in Tamil. The gelatinous pulp gradually hardens into a bony kernel and develops a fibrous coat. Male and female palms can be distinguished only when they start flowering which occurs after 15-20 years of growth.

Flowering season: starts from January and continues till August with a peak during May.

Tapping season : Female palms = April – Dec, (8 to 9 months)

Male palms = Dec – Feb, (2 to 3 months)

Question bank

1. Botanical name of palmyrah palm is ----- (*Borassus flabellifer*)
2. Palmyrah cultivation is in ----- and ----- states in India (Tamil Nadu & Andhra Pradesh)
3. Mention any two species of palmyrah palm
4. Write about the uses of palmyrah palm
5. Palmyrah palm is called as Kalpakatharu - justify

LECTURE 16

Climate and soil

Climate:

Rainfall: It can come up in dry areas having moderate to low rainfall.

High temperature and Heavy wind

Altitude : It grows from sea level up to an altitude of 750m.

Soil:

It prefers deep, sandy and loamy soils, though can come up on varied types of soils. The most congenial situations for its favorable development are Low sandy plains. It is distinctly wild and propagates itself readily from seed in regions where it is abundant. In such regions it is capable of forming pure forests or forests intermixed with wild date palm (*Phoenix sylvestris* Roxb). It some times acts as a wind break for the plains.

Soil depth : > 2m

Palm Jaggary grown on calcarius soil are more sweeter

Varieties: There is no recognized variety.

Based on fruit type (colour of fruit pericarp) there are groups of palms viz,

Black skin : are generally more sweet and

red skin / Golden skin fruit types : Fruit and nut number per tree is more than black fruits but are generally less sweet

SVPR-1: Palmyra research station, Srivaliputhur (T.N.A.U.) has released one improved variety namely SVPR-1 Palmyra palm.

Features

semi-dwarf type

High padaneer yield of 298 litres per palm in a tapping duration of 95 days.

Quality of padaneer : The padaneer of this variety has a high jaggery content (144 g per litre of padaneer i.e., 14.40 %) and a high brix content.

Propagation:

LECTURE 16

Seed propagation :

Nursery raised seedling and

Self sown seedlings are used for propagation

Mother palm selection in palmyra

Age of the palm : Middle aged – 30 to 40 years

Stature of canopy : Dwarf and stout palms are selected. Trees with compact leaves are preferred to long slender stemmed trees

Selection of seed nuts

Stage of maturity : From the fruits which are 80 to 90 per cent ripe. Heap the selected fruit bunches for 5 to 6 days for automatic stripping from bunches == Select plummy and healthy seed nut.

Removal of mesocarp : Allow fruits to ferment for easy removal of mesocarp. While removing mesocarp, the fibre adhering to seed nut should be retained which help in absorption of water and leading to better germination.

Sex of nuts :

Seeds of single nut give == female trees

Double nuts give == One female and one male

Trinuts === Two male and one female

To maintain male and female ratios it is better to collect 10 to 15 per cent of double nuts.

Seed propagation in palmyra palm.

Mature (fully) fruits – - shade storage (three weeks) - - Sowing – three weeks --- germination ----- 150 to 160 days = for first leaf to come out of soil.

In palmyra palm first sheath of the cotyledon elongates and after it has gone into soil the radicle comes out and produces the root. It forms tuber and eventually the plumule bursts the plumule sheath (i.e., coleoptile) and forms shoot.

Seed nuts collected from a identified mother palm (of 30 to 40 years age) are stored in shade for 3 weeks. These seeds may be directly sown in si tu or sown in nursery to raise the

LECTURE 16

seedlings. The seeds of palmyrah should be either planted in the permanent place or in deep container. It is because emerging shoot will go deep into the soil as tuber, up to 1 m depth in the beginning and later it comes upwards and produces leaves when tubers start rooting.

The plumule coming out initially utilizes the food material stored in the seed nut. This germinated part goes down into the earth as a tuber and when the tuber matures, rooting starts, == Which absorbs the soil nutrients == After this leaves come out one after the other.

. In the earlier stages of germination only the underground portion of the stem increases in thickness (Palmyra seedlings have tuber above the root). If there is restriction the growth of the seedling will be affected.

For direct sowing 3 - 4 whole fruits are planted in pits half filled with sand or sand and soil mixture. Seeds start germinating in 3 weeks.

Spacing in nursery : at 10 cm apart and covered with 5 cm sand. Follow nursery techniques during the initial period. One year old seedlings are lifted from the nursery and containerized in the polythene bags. After roots are formed the seedlings can be successfully transplanted in the main field.

Cultural Aspects / After Cultivation

No organized cultivation is practiced. Seeds fallen in the existing plantations == Self sown seeds germinate and establish.

The palm grown naturally and no particular cultivation is necessary. It requires no artificial irrigation or manuring. However, for better performance following cultivation practices are suggested.

Planting :

Pit size : 30 x 30 x 60 cm at

Spacing : 3m x 3m (450 plants /ha)

LECTURE 16

If triangular system of planting is adopted it accommodates 500 trees per ha.

Note : Seeds can also be directly sown in the field 5 cm below soil surface with seed eye facing down ward to the soil.

Manuring:

Prevailing practice – Before sowing of nuts = 10 kg FYM per pit is applied – Increased biennially till the dose reaches – 60 kg per pit per year.

A dose of 10 kg FYM per pit is applied before planting and it has to be increased biannually till it reaches 60 kg FYM/pit/year.

Gap filling: After cultivation consists of gap filling. Gap filling may be carried out using containerized seedlings.

inter ploughing,

Basin rectification in the initial few years. Basin rectification before rains helps for efficient collection and storage of rainwater.

Defoliation:

Tending : Removal of persisting leaf bases (Tending) has to be attended in Palmyra periodically.

Intercrops: Upto initial 5 to 6 years == Seasonal crops = Cowpea, moringa, green gram, red gram, Bengal gram,

Mixed crops: With semi arid zone fruit cops like , Anona, ber, amla, pomegranate, moringa, carissa, west Indian cherry, guava etc appears to be good. (Phyllanthus emblica = Bettadannelli while P. acidus is Indian goose berry,)

Irrigation : In dry lands pitcher irrigation may be followed. Soil conservation measures Viz.,
Mulching,
Forming basin,
Rain pits,
Legume cover crops etc be adopted.

LECTURE 16

Plant protection

Pests: As in coconut

rhinoceros beetles,

red palm weevils and

black headed caterpillar

Eriophid mite often cause damage.

Diseases :

Bud rot ,stem bleeding, Grey blight and tuber rot

Bud rot : The palm is liable to infection *Phytophthora palmivora* Buttler, causing a serious fungal disease called “bud rot”. In the advanced stage of the disease the soft heart of the bud is converted into a foul – smelling, rotten mass and the tree dies.

Control : Prophylactic spray and curative spray of Bordeaux mixture (1 %) spray or Fytolon (0.3 % spray) is suggested.

Tapping

The extraction of sap from the inflorescence is called tapping which is the most important use of this palm. Tapping varies with the age and sex of the palm.

Edible products of palmyra : Neera, Toddy, Sugar, Jaggary, Candy, Vinegar etc

Commercial products of palmyra : Wood, leaves, roots, Fibre, fruit pulp, fruit fibre etc.

Male palms : Only Neera is obtained

Female palms :

Neera, Fruits, and tubers from palmyra seeds can be obtained.

It yields 30 to 50 per cent more sap than male palms.

Age at first tapping : 10 to 12 years after planting if properly managed otherwise it is about 15 years.

Economical life /Yielding age : The trees continue to yield for 30 to 40 years.

LECTURE 16

The spadices of palmyrah, on tapping yield a delicious sugary sap, known as the sweet toddy

Neera on fermentation gives toddy

Palmyrah is extensively tapped for the sweet sap which is fermented into country liquor (toddy) or boiled into raw sugar. Trees of both sexes are tapped though the female palms are yielding 35 to 50 per cent more sap than male palms .

Tapping: = Extraction of sap from the inflorescence is called tapping.

Method of tapping: It varies with sex of the palm and age of inflorescence.

Male palm: The sheath covering the young inflorescence (two weeks old) is removed and allowed to dry for three days. The end is cut every time and pot is tied to the inflorescence. Thus in case male palms the flowering shoots are tapped.

A. Male palms: Tapping period = short period (Dec- Feb)

1. Aripantai Method: In male palm sheath of young inflorescence (using 2 weeks old inflorescence) is removed and allowed to dry for three days. The end is cut every time and pot is tied to the inflorescence. It is practiced for 1 to 1 ½ months.

2. Vellupantai : (Using comparatively old inflorescence of one month)Here also male palms are selected but inflorescences are of one month old. Each male spike (bearing sessile flowers) is pretreated by pressing and stroking (pettu/hodeta). Three to 6 such spikes are brought together, wrapped with palmyrah leaves and fitted to a pot.

Female palm: The tissues of young female inflorescence are softened by hitting the main axis of the inflorescence with iron rod and the fork is used to press the regions from which the fruits develop. Thus in case of female palms the fruiting branches are tapped when the drupes are still very small.

B. Female palms: Tapped for longer period, i.e., April - December . It gives 30 to 50 per cent more sap yield.

LECTURE 16

1. Thattipalai : Young female inflorescence is tapped in this method. The tappers soften the tissues by hitting the inflorescence main axis with the iron rod and fork is used to press the region from which fruit develop.

2. Kaivetty:: When female inflorescence is about 2 to 3 months old. Here the inflorescences are matured and will be having fruits. In this method fruits are sliced as the tapping progress.

Yield:

Fruit yield == only in female palms == 50 to 200 fruits in 6 to 12 bunches per tree per year

Question bank

- 1.Narrate the soil and climatic requirement of palmyrah palm
2. ----- is the released variety in palmyrah palm (SVPR 1)
3. Narrate propagation in palmyrah palm
4. Write about tapping in palmyrah palm
5. Main product in palmyrah palm is ----- (Padaneer)

LECTURE 17

Oil palm: (*Elaeis guineensis* Jacq. = African oil palm)

Family = Arecaceae /i.e.,Palmae,

Introduction: Oil palm is the highest edible oil yielding crop (4 to 6 tonnes of oil/ha from 3 to 25 years of its life span.) compared to less than one tonne of oil per ha from other cultivated oil yielding crops.

Sl. No.	Crop	Oil yield (tones per ha)
1	Oil palm	4 to 6
2	Coconut	0.65 to 1.5
3	Ground nut	0.35 to 0.45

India is importing about 5 to 8 lakh tones of palm oil every year from Malesia, Indonesia for Public Distribution system (PDS).

Palm oil : From fleshy mesocarp (It contains 45 to 55 % oil)
(Olive oil is also obtained from mesocarp)

Palm kernel oil : From stoney seed (It contains 50 % oil)

OIL palm research in India

- 1) NRC for Oil Palm = National Research Centre for oil palm,
Elur, PEDAVEGI- 534 450, West Godavari Dist. AP

Origin of Oil palm

Origin: Africa (West Africa). Oil palm originated from West Africa from where it spread to America and far East.

In tropical rain forest of West Africa i.e., Guinea coast of West Africa.

LECTURE 17

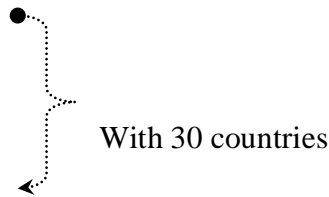
It is available in wild, semiwild and cultivated forms in

- 🌍 Africa,
- 🌍 S.E. Assia,
- 🌍 America.

Distribution of oil palm

World :

Regions: South East Asia,
West Africa,
Latin America



Countries growing oil palm

- ❖ Malaysia = Largest producer of oil palm in the world, other countries includes. It produces 58 per cent of world oil palm production from 55 per cent of world area under oil palm. Malaysia -2.2 m ha under oil palm out of world acreage of 4 m ha. It produces 7.5 m tones of oil out of world production of 13 m tones of palm oil.

Oil palm is cultivated in roughly 4 m ha in the world to yield about 13 million tones of oil.

Area and production of oilpalm in world

	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
Indonesia	5000000	172000	86000000
Malaysia	4002000	211999	84842000
Nigeria	3200000	26562	8500000
Thailand	510213	159979	8162380
Colombia	165000	193939	3200000
Ghana	352800	59625	2103600

LECTURE 17

Ecuador	135000	155555	2100000
Papua New Guinea	119000	145378	1730000
Cameroon	77000	207792	1600000
Honduras	100000	152600	1526000
Total	14921224		210326644

India is importing about 5 to 8 lakh tones of palm oil every year from Malesia, Indonesia for Public Distribution system (PDS)

Oil palm in India

1846 : Introduction of oil palm as an ornamental crop in India

1890 :Introduction of oil palm in India at National Botanical Garden, Culcutta

1960 : Introduction of oil palm to our country was done systematically. Oil palm was raised in a plantation scale in an area of 40 ha in 1960 at Thodupuzha, Kerala where research Station for oil palm was started in 1960

1971 : Large scale oil palm plantation development in Kerala. Two commercial plantations were initially established at Andaman and Kerala (1971 -1982).

1971-81 : Oil palm attained commercial status in India

1995 : Establishment of NRC on Oil palm

1990-91 : Department of Biotechnology in collaboration with Govt of AP, Karnataka and Maharastra to up planting of oil palm in 1000 ha area to demonstrate feasibility of oil palm cultivation under irrigated conditions.

AP : Krishna, East Godavari and West Godavari

Karnataka : Shimogga

Maharastra : Sindhadurga Dist

In Kerala the area under oil palm is rainfed (4 months dry spell) while in AP and Karnataka it is mainly irrigated

Potential area that can be brought under oilpalm in India

LECTURE 17

State	Potential Area In Ha.
Andhra Pradesh	4,00,000
Chhattisgarh	40,000
Goa	2,000
Gujarat	90,000
Karnataka	2,50,000
Kerala	6,500
Mizoram	61,000
Orissa	25,000
Tamil Nadu	1,62,000
Total	10,36,500

➤ 80,000ha of which

➔ AP = 50,000 ha : Especially in coastal Dist of AP

➔ Karnataka = 20,000 ha

AP and Karnataka together constitutes 80 per cent of area under rubber.

and

➔ Tamil Nadu =8,000 ha

➔ Other states(Gujarat, Orissa, WB, Assam and Tripura) =Remaining area.

Why large scale production of oil palm is necessary in India ?

Need for large scale oil palm cultivation in India

Short supply of edible oil produced in our country. India is having an area of about 19 to 20 million ha under various annual oil seed crops viz., Ground nut, Rape/mustard, Sesame, Sunflower, Soybean etc.,

Oil requirement

Per capita edible oil consumption as per ICMR recommendation :10 kg/head/year

Indian average oil consumption (at present) : 6 kg /head/year

World average : 12 kg/head/year

LECTURE 17

2. Oil palm is an answer to the growing demand of edible oil :

Yield of oil from oil palm = 4 to 6 tonnes per ha compared to less than one tones per ha from other cultivated oil seed crops (while other oil seed crops yield < 599 kg oil per ha (i.e., < 0.60 tones per ha)). If five lakh ha of area suitable area for oil palm cultivation is developed under oil palm (Agroclimatic conditions) the demand and supply gap (Production and consumption gap) can be successfully met.

3. Economic importance of oil palm :

- a. Oil palm is the richest source of edible oil yielding 4 to 6 tones per ha per year thereby yielding high economic returns.
- b. High employment potential,
- c. Raw material for industries :
 - i. Vanaspati industry,
 - ii. Soap industry
 - iii. Production of oleochemicals products such as fatty acids, fatty alcohols, glycerols and other derivatives. (These are used for the manufacture of cosmetics, pharmaceuticals, detergents and industrial products,).
- d. By-product utilization:
 1. Fiber from fronds and empty fruit bunches are used to make medium density fiber boards.
 2. Furnitures : From trunk,
 3. Mushroom cultivation : Empty bunch can be utilized as a medium for mushroom growth.

4.Environmental Protection: Environmental stability: It is important for maintaining environmental stability.

- e. Suitable for sustainable agriculture,

It is believed that, India will be an important producer of palm oil in the immediate future. Andra Pradesh and Karnataka have greater potential for oil palm cultivation in the major irrigated areas.

LECTURE 17

Constraints in the development of oil palm in India.

(In identified irrigated project areas)

- 1) Acceptance by farmers : It is required to educate farmers so as to convince them accept oil palm cultivation (which is totally new crop to India) by replacing existing crops in some areas. Follow up. Demonstration plots of 55 palms each have been established.
- 2) Long pre bearing period : The long juvenile period (>3 years) of atleast 3 ½ years for getting yield makes the necessity of
 - a) Institutional finance: Through lead bank and NABARD etc.
 - b) Incentives to take up oil palm cultivation ---Eg. Subsidized inputs and planting materials, irrigation facility etc.
 - c) Buy back guarantee:
- 3) Availability of quality planting material : Though seedlings are produced at CPCRI Research Center at Palode, there is need to import quality planting materials from other countries.

4) Processing facility at reasonable distance: Since fruit bunches have to be crushed within 24 hours of harvest, simultaneous establishment of processing units is necessary. Assured and timely procurement of FFB from the farmer is suggested.

Public sector companies are coming forward for the establishment of factories.

4) Size of holding in India is very small : To run a processing unit profitably the plantation should be on a large scale.

Question bank

1. Botanical name of oil palm is ----- (*Elaeis guineensis*)
2. What is the difference between palm oil and palm kernel oil?
3. NRC for oil palm is situated at ----- (Elur, Pedavegi)
4. Write about the distribution of oil palm in India
5. Why there is a need for large scale oil palm cultivation in India?

LECTURE 18

Soil and climatic requirement

Soil:

- Deep permeable soil rich in humus. Depth should be at least 1 m (> 1m)
- Optimum $P^H = 6.5$ to 7.5
- Avoid heavy soils with poor drainage, highly alkaline soils and soils with more of gravel and sand with poor water holding capacity.

Climate: Oil palm is categorized as a humid tropical palm.

- ❖ Sun light :It is a sun loving plant , Requires bright sunshine of more than 5 hours . Solar radiation below $350 \text{ cal /cm}^2 /\text{day}$ affects the growth and yield of the palm
- ❖ Temperature : Prefers hot humid equatorial climate with a mean annual temperature of 20°C to 27°C , and temperature of more than i.e., $> 33^\circ \text{C}$ inhibits photosynthesis.
- ❖ Altitude /Elevation : Oil palm can be grown upto 900 m. ASL. But below 450 m ASL it's performance is better.
- ❖ Rainfall : Well distributed rainfall of 2500 to 4000 mm. It can with stand high rainfall and 3 to 4 dry months in a year. However, dry period affects yield adversely with poor sex ratio.

Hence, cultivation of oil palm under rain-fed situation may not be profitable

Sex ratio in oil palm

Sex ratio in oil palm is defined as the number of female inflorescence over the total number of inflorescences produced for a given period

Sex ratio = $\frac{\text{No. Of female inflorescence}}{\text{Total no. Of inflorescence (i.e., male + female)}} \times 100$

Total no. Of inflorescence (i.e., male + female)

There are three different types of oil palm namely dura, pisifera and tenera based on their fruit forms. The significant differences among the three types are the presence or absence of shell and the thickness of shell.

Varieties in oil palm

1) Dura : Have low to medium mesocarp (35 to 55 %) and it contains a thick shell around the kernel . It is not preferred for commercial cultivation. Shell thickness

LECTURE 18

Mesocarp = 35- 55 % (54 % by weight),

Shell = 30% by weight

Kernel= 16 % by weight

Shell thick ness = 2 to 8 mm

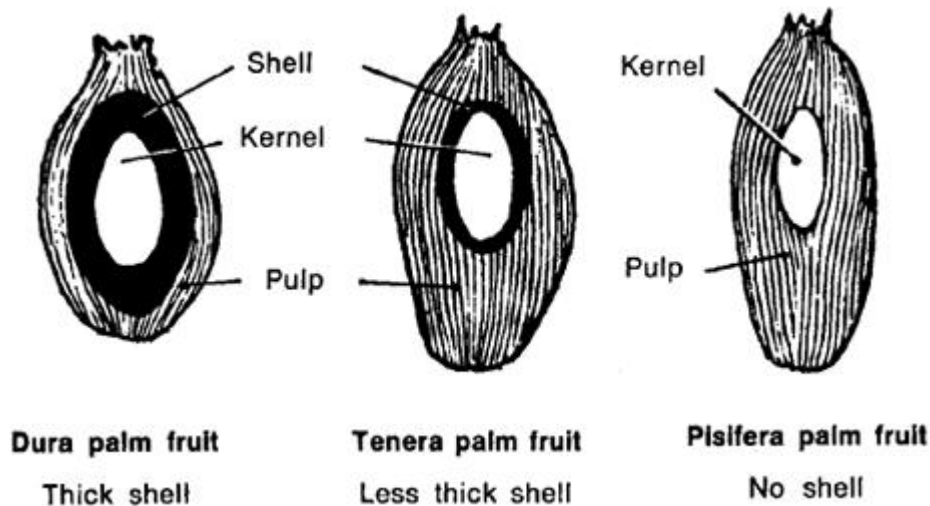
2)Tenera : It is a hybrid i.e., = Dura (Female) x Pisifera (male) = Tenera (F1 hybrid)

It is commercially/ widely cultivated all over the world due to high proportion of mesocarp (60 to 95 %). It is characterized by the presence of thin shell. Tenera is characterized by the presence of distinct ring of fibres embedded in the mesocarp near to and encircling the seed. Tenera fruits have a lot of pulp. Thin shell and a big kernel.

Mesocarp = 60 to 95 % (74 % by weight)

Shell = 10 % by weight

Kernel = 16 %



3) Pisifera: It is a shell less fruit and pea like kernel inside. Embryo abortion is common in this variety and often kernel is also absent. The presence or absence of shell is genetically controlled. Dura is a genetic constitution of $Sh^+ Sh^+$ while Pisifera is Sh^-, Sh^- and hybrid is $Sh^+ Sh^-$. On selfing or intercrossing, the hybrid fruits forms segregate in to 25 % Dura, 50 % Tenera and 25 % Pisifera.

LECTURE 18

Mesocarp = 90 % by weight

Kernel = 10 %

Note : In Pisifera seed propagation is not possible as many of the fruits do not have embryo. Embryo abortion is common in this variety and often kernel is also absent. It is used as male parent in the production of Tenera. Pisifera palms are generally recovered from segregating populations since direct reproduction of this type is difficult due to the scarcity of fruits with embryo and the absence of protective shell.

Table: Features differentiating fruit types of oil palm,

Sl. No	Characters/Composition	Dura	Tenera	Pisifera
1	Mesocarp proportion in fruit (%)	35-50	60 –96	98
2	Shell thickness (mm)	2 to 8	0.5 to 4	--
3	Oil percentage	15 %	36 %	25 %
4	Average proportion of shell in fruit (%)	30	10	--
5	Average proportion of kernel in fruit (%)	16	16	10

Type of progenies as a result of

- a) Durra x Pisifera b) Dura x Dura c) Tenera x Tenera

Dura = Sh⁺ Sh⁺

Tenera = Sh⁺ Sh⁻

Pisifera = Sh⁻ Sh⁻

Propagation in oil palm :

Germination period in oil palm : Under natural conditions it takes about two years for germination in oil palm

Mode of Propagation : Seeds

Planting and after care:

Planting:

Season : May – June,

Method/ System of planting :

Systems of planting: Generally square and

Triangular systems of planting are used but the most commercially used method is triangular system.

LECTURE 18

Age and stage of seedling at the time of planting : 10 to 14 months (some times 12 to 18 months stage). At this stage seedling will have 13 leaves, and about 1 to 1.30 m ht with good collar girth.

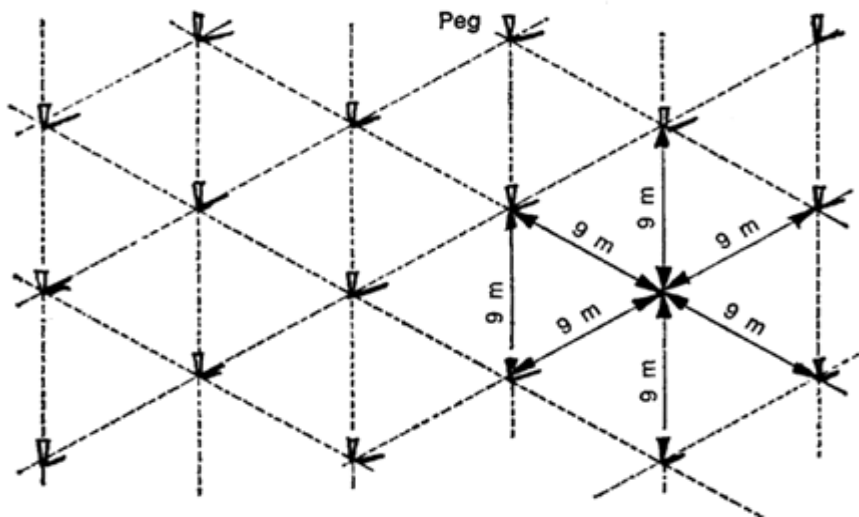
Pit size : 60 cm x 60 cm x 60 cm

Spacing: 9 m x 9 m (140 to 150 trees per ha in triangular system of planting)

Or

10 m x 10 m.

Fill the pits with FYM,+ Top soil + 125 g P_2O_5



- 1) Seedlings are protected from rodents whenever necessary by wire netting (45 x 120 cm) encircling at a radius of 15 cm from base.
- 2) Take care of maintenance during initial period of establishment.

Manuring :

FYM = 50 kg per palm per year. (Or 50 to 100 kg). or 100 kg green manure.

Neem cake : Addition of neem cake @ 5 kg per palm is also beneficial.

LECTURE 18

Fertilizers:

Table: Fertilizer recommendation for oil palm (g. per palm)

Season→	May – June(Pre monsoon)			Sept- October(Post monsoon)			
Fertilizer →	N	P ₂ O ₅	MgSO ₄	N	P ₂ O ₅	K ₂ O	MgSO ₄
Age↓							
Before Planting	---	125	----	----	-----	----	---
I Year	200	100	200	200	100	200	125 g
II Year	400	200	400	400	200	400	250g
III yr. And above	600	300	600	600	300	600	500g

Full dose for adult palm includes: 1200g N, 600 g P₂O₅ and 1200 g K₂O per year.

Deficiencies of micronutrients in Oil palm

Mg and Boron deficiency has been observed in Oil palm

Magnesium (Mg) deficiency : Olive green coloured areas appear on the pinna of older leaves and the yellow colour spreads down towards the frond midrib until the whole pinna become a deep orange in colour

Mg deficiency occurs due to heavy application of K fertilizer i.e., when ratio of K: Mg exceeds five (5).

Boron deficiency : Hook leaves, (or it is also termed as Blind leaf or Bristle leaf)

Apply 75 to 100 g of Borax (Sodium Borate) per palm. We can also use solubor for the foliar spray @ 0.1 per cent.

Note:

1)

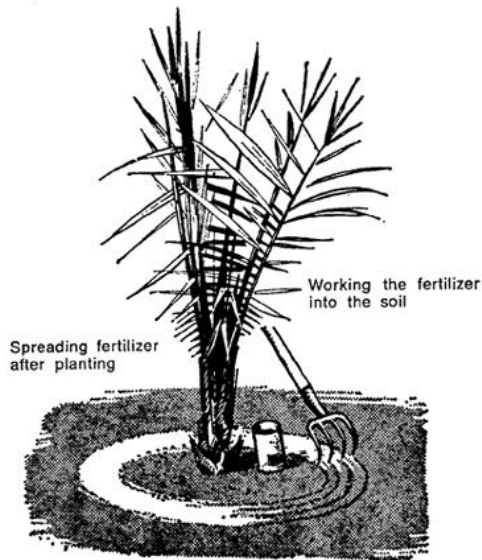
👤 Supply Mg (@500g per palm per year) if deficiency symptoms are noticed.

👤 Borax @ 100 g per palm per year if boron deficiency is observed.

LECTURE 18

2) Under irrigated conditions, it is preferable to apply nitrogenous and potassium fertilizers in as many splits as possible to increase the fertilizer use efficiency.

Method of fertilizer application in oil palm :



Apply fertilizer at the base of the palm leaving 1 to 2 ft basal area undisturbed.

Depth of application : 1 to 2 inches and mix with soil.

Basin management /Size of palm basin in oil palm

Widen the basin as and when tree grows.

I year of planting : 1 m radius

II year of planting : 2 m radius

III year and above : 3 m radius.

Basin space must be meant only for the oil palm and should be free from weeds and any inter/mix crops.

Note :

- 1) Spread fertilizer in the ring underneath the largest leaves and after spreading cover with a thin layer of soil.
- 2) If plants are mulched, remove the mulching material and spread fertilizer and spread a fresh mulch of dry herbage to a thickness of 15 to 20 cm.

LECTURE 18

Irrigation

Irrigation at the rate of 100 liters of water per palm per day (100 to 150 liters per palm per day and even upto 200 liters per palm per day in hot summer) has to be provided during dry period to realize the yield potential of the palm.

Yield increase in oil palm under irrigation is attributed to;

- 1) Increased leaf production,
- 2) Increase in number of bunches,
- 3) Better sex ratio and
- 4) Reduction in abortion of female inflorescences.

After 28 months of irrigation increase was from 1 tones per ha to 4.50 tonnes per ha.

Drip irrigation : Four drippers discharging of 150 to 200 liters in 5 to 6 hours

Cover cropping

1. *Pueraria phaseoloides*
2. *P. javanica*,
3. *Calapogonium muconoides*,
4. *Centrosema pubescens*
5. *Mimosa invisa*
6. *Macuna bracteata* - A cover crop introduced in Kerala from Tripura,. It is not flowering under KAU conditions. Hence, propagated through stem cuttings.

Seed rate : 2 to 3 kg per ha

Establishment of cover crops

Seed treatment:

a) Hot water treatment (50 – 60° C) : Soaking of seeds for 2 hours improves establishment resulting in good cover.

b) Rhizobium culture: @ 1 g per kg of seed.

LECTURE 18

Leaf Pruning in oil palm

Development of leaves in the crown of palm is initially slow. Each leaf remains enclosed for about 2 years and then develops into a central spear (spindle leaf) before opening. The leaf stalk is strong and fibrous and is almost 8m long. A mature leaf may have 250-300 leaflets; each about 1.3m long and 6cm broad.

Rate of leaf production in oil palm : 20 to 25 leaves per year . Each leaf will also carry one inflorescence.

Persistence of leaves in oil palm : The leaf bases adhere to the stem for about 12 years and longer and fall away gradually.

Fronde pruning in oil palm has influence on yield and hence is of economic importance.

If pruning of frond has not been attended it results in

- ❖ 1) Interferes with the pollination, (Both assisted and natural)
- ❖ 2) Visual assessment of fruit ripeness.,

Excessive pruning is harmful i.e., Causes reduction in yield.

Immature (Pre bearing period) : Removal of senescent and useless fronds which are lying very close to the soil surface.

(Annual leaf production in areca = about 6 while in coconut = 12 to14 leaves, oil palm = 24 leaves)

Adult palms: About 32 to 35 top leaves are left undisturbed on adult palms. (Each palm produces about 24 leaves annually i.e., 2 leaves per month)

Ablation in oil palm :

It refers to the removal of young male and female inflorescences and bunches during the first three years of oil palm growth.

(Ablation = Removal / Surgical removal of any part of the body). Other terms used for ablation operation are

- 👤 Dis budding,
- 👤 Debudding,
- 👤 Deflowering

LECTURE 18

Frequency of ablation :Ablation should be done at monthly intervals by cutting with the help of narrow bladed chisel.

Purposes of ablation:

- 1.** Uneconomic processing by collection of few bunches in the initial years of bearing,
- 2.** Left over bunches may rot and lead to outbreak of diseases and pests.
- 3.** Divert ion of nutrients for palm growth from theses bunches and inflorescences. --- Results in to uniform palm stand.

Period of ablation:

14 to 26 months after planting. Ablation can be commenced after about 14 months of field planting and continued till 26 months when about 70 per cent of palms are producing inflorescences (at an interval of 4 to 5 months = ?)

Question Bank

1. Write about the sex ratio in oil palm
2. Describe about Tenera hybrid in oil palm
3. Write about the spacing and method of planting in oil palm
4. Why there is need for leaf pruning in oil palm?
5. What do you mean by ablation in oil palm?

LECTURE 19

Management / Control of Rodents Damage in oil palm

Rodents / rat damage

Control/ Management :

- 1) Trapping : Different baits such as Iron Live traps, Snap traps, Death fall traps, Bow trap, Cage trap, Spring death trap, Bamboo nose Trap may be used to minimize rat damage.
- 2) Orchard Sanitation
- 3) Poison Baiting :
Acute rate poison : Rodenticides such as Zinc phosphoid, single dose anticoagulants like Bromadiolone ((0.005%)
Multiple Dose anticoagulant rodenticides : Warfarin, Fumarin are placed in the field in the evening and removed in the morning
Dead rats should be buried to avoid secondary poisoning
- 4) Mechanical Barriers : Oil palm seedling at the time of planting can be covered with 22 gauge galvanized iron (Chicken) wire mesh around bole as prophylactic measure against rats, porcupines etc
- 5) Biological agents :
Predators for rats includes a) Snacks, b) Vultures, c) Mongoose d) Cats and e) Dogs.

Diseases in oil palm

- 1) Spear rot 2) Bud rot and 3) Bunch failure are the major diseases of oil palm.
- 4) Basal stem rot (*Ganoderma disease*)

(1) Spear rot:

It is a lethal and infectious disease found in the oil palm plantations of Kerala.

Cause :

- 1) Several micro organisms are associated with this disease and most common ones are

Fungi viz.,

Fusarium moniliformae and *Collatotrichum gloesporioides*

- 2) MLO and 3) Bacteria

LECTURE 19

Symptoms:

1) Yellowing of the youngest whorl of the unfolded leaves: Yellowing of the youngest whorl of the unfolded leaves is the initial symptom. Yellowing starts from the tips of leaves and spreads mostly along the margins of leaflets.

The chlorotic area later turns brown and dries up.

Management: In view of uncertain etiology

1) Rouging : Rouging of the affected palm is recommended to prevent the spread of this malady. We have to go for rouging RWD (root wilt disease in coconut) and YLD affected coconut and arecanut palms also from the vicinity.

Barrier trees : Raising quick growing barrier trees in the border of the plantation to prevent vector movement from RWD/YLD source

Disorders in oil palm

Bunch failure: Failure in the development of bunches at any stage during anthesis to harvest is referred as bunch failure. Periodical palm cleaning reduces the load of inoculums and fresh incidence.

Cause : Not specifically known

- 1) Excess pruning,
- 2) mutual shading,
- 3) under pollination : Release of pollinating weevil
- 4) Moisture stress/ Prolonged drought
- 5) Inadequate nutrient status
- 6) Over bearing etc ., increases bunch failure.

Control measures: There is no recovery once bunch failure has started and hence all control measures must be aimed at avoiding those conditions favoring bunch failure.

Harvesting, Processing and yield in oil palm:

Pre bearing age in oil palm : 3 years

Economical life : 25 years

LECTURE 19



If the clusters are too high up to be cut with the longarmed sickle, use bamboo ladders, or else climb up the tree with a belt; you can also wear spiked shoes.

First harvest in oil palm starts in 3 ½ to 4 years after planting.

Fruit maturity period from the period of flowering : It takes about 180 days (6 months) from pollination to maturity.

Stage of harvest:

Fully ripe fruit bunches are harvested. Immature bunches and partially rotten bunches are not suited because it results in low oil recovery of poor quality.

1) Change in colour :When colour of fruits changes from black to orange or red or yellowish orange.

2) Detachment of fruits : For practical purposes when few fruits (say around 10 fruits or more detached or easily removable for young palm and 5 fruits for adult palm) are detached from the bunch.

3) Change in fruit texture : Fruits become smooth when ripe and fruits can be pressed with fingers with ease.

LECTURE 19

Over ripe fruits reduces quantity and quality of oil. If harvesting is delayed the fat is converted to free fatty acids and glycerol.

Harvesting is done at ripe stage and if it is delayed the fat is converted to free fatty acids and glycerol.

Harvesting interval :

As the oil synthesis and free fatty acids formation occur during ripening process, harvesting should be carried out as frequently as possible in order to reduce the number of over ripe bunches. Over ripe bunches have a high degree of fruit detachment and have increased oil acidity. According to current practices, harvesting should be done at every 7 to 14 days intervals.

Harvesting tools:

When palms are young.====Chisel attached to the tip of 1.2 to 1.5 m long stick of wood or of light hollow metal pipe with a handle

When palms grow older use wider chisel (about 14 cm wide) and a longer stick.

Harvested fresh fruit bunches (FFB) have to be transported to the factory as quickly as possible and at any cost not later than one day (Within 24 hours).

Processing and yield: The fruits of oil palm should be processed within few hours after harvest to obtain good quality oil. There will be deterioration of oil due to over ripening, storage, damage of fruits, etc. The usual method of processing (dry process) involves sterilisation, stripping, fruit digestion, pressing, clarification, etc. Edible palm oil should contain less than 2 % free fatty acids.

Sl. No.	Features	Palm oil	Palm kernel oil
1	Part of fruit used	Mesocarp	Kernel or endosperm
2	Oil percentage in the fruit part used	45 to 55 %	50 %

LECTURE 19

3	Colour	Light yellow to orange red depending on the amount of carotenoids present	Resembles coconut oil i.e., nearly colorless
---	--------	---	--

Processing for palm oil extraction:

As oil is extracted from mesocarp portion of fruit the method of oil extraction is entirely different i.e., wet processing.

One of the major problems in oil extraction in oil palm is deterioration of oil into free fatty acids which results in poor quality of oil. Factors affecting quality of oil by increasing FFA (Free fatty acid content should be less than 2 % for using it as edible oil)

Time gap between harvesting and processing of FFB : 24 hours.

Fruit bunches of oil palm (FFB) should be processed within 24 hours of after harvest to get good quality of oil.

During processing oil palm fresh fruit bunches are sterilized in steam/boiling water for 30 to 60 minutes to inactivate the fat splitting enzymes.

- 1) Bruising (Crush/pound)
- 2) Bad handling
- 3) Delayed processing
- 4) Over ripe fruit bunches.

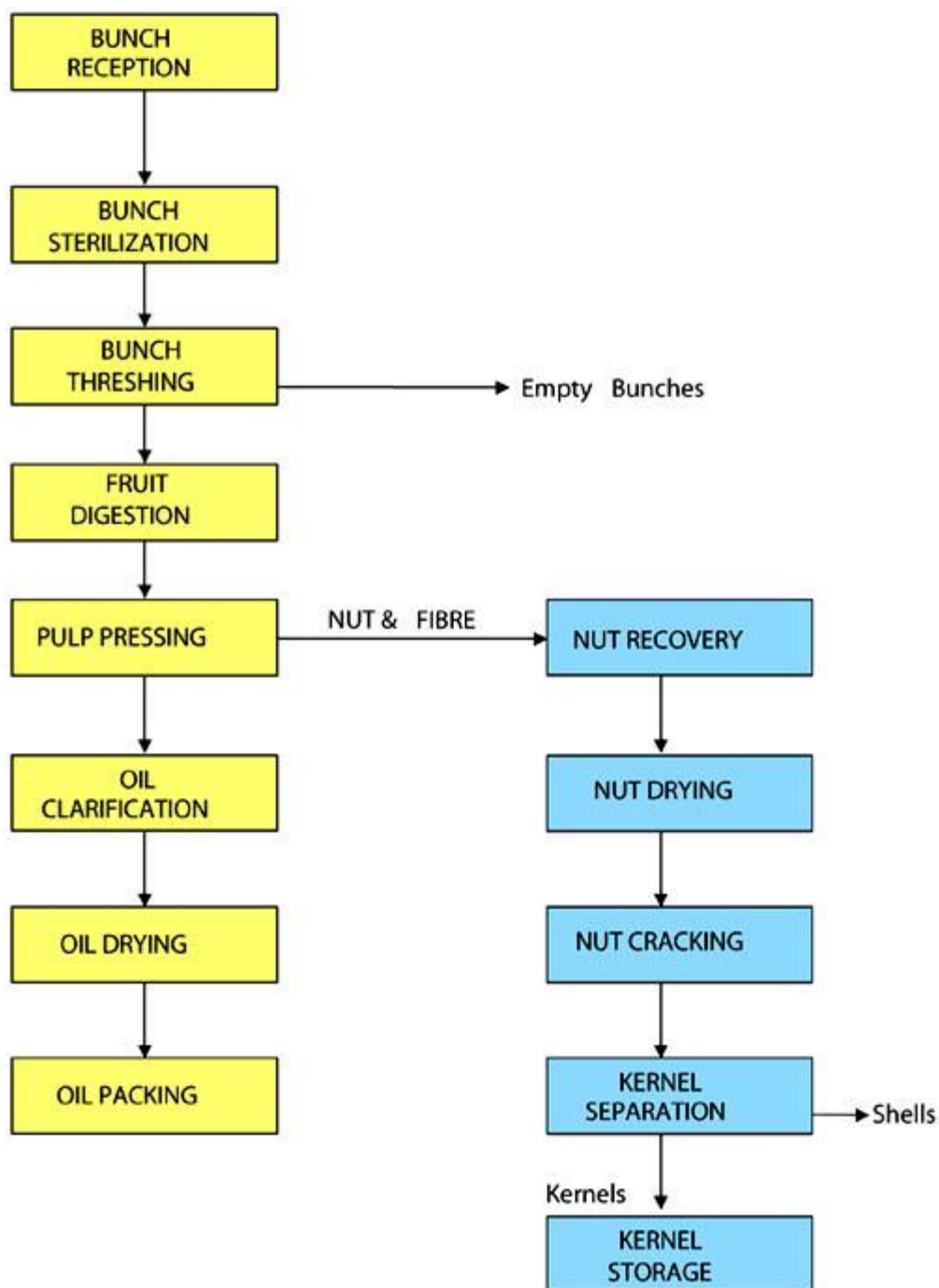
Fruit bunches are to be processed within 24 hours of harvesting. If at all it has to be stored, it has to be sterilized and stored

Sterilization of FFB: After harvesting bunches are sterilized at 130 °C for one hour under pressure of 2 kg per cm².

Stages of processing

PALM OIL PROCESSING UNIT OPERATIONS

LECTURE 19



Sterillization brings about

- 1) Inactivation of lipase and lypolytic enzyme activity i.e., fat splitting enzyme which are responsible for increase in FFA.
- 2) Loosening of fruits for easy separation
- 3) Softening of fruits facilitating digestion,
- 4) Coagulation of mesocarp proteins.

LECTURE 19

2) Stripping: Fruits are separated from the bunches.

How?

3) Fruit digestion : During digestion process there will be release of oil from the pulp i.e. conversion in to oily slurry (mesocarp)

How ?

4) Pressing : Separation of liquid component from thee solid.

5) Clarification : Oil is cleaned of water, cell debris and particles of fibre and shell.

Crude palm oil === Refining ---- Palmolein ----- Further purified

Palmolein has thick consistency , red colour,

Production of Edible oil

< 2 per cent free fatty acid content : In edible oil the free fatty acid content should not exceed 2 per cent .

At present in India the oil produced is of poor quality due to bad quality of FFB supplied from farmers.

If quality FFB is supplied to the processing units production of edible grade oil can be (i.e., < 2 % Free fatty acids) achieved.

Yield:

LECTURE 19

The average weight of harvested fruit bunches will be = 30kg

Average number of bunches per palm = 10 to 12

Average bunch weight : 30 to 40 kg /bunch

Average FFB yield per year per ha = 12 tonnes

Oil recovery out of FFB : 18 to 21 % i.e., Extraction ratio from oil to bunch=20 %

Under good management

FFB = 20 to 30 tonnes per ha yielding 4 to 6 tonnes of oil. However, on an average 12 tonnes of fresh fruit bunches (FFB) can be obtained per ha per year, yielding 2.5 tonnes of palm oil.

Question bank

1. Explain the reasons and remedies for bunch failure in oil palm
2. Pre bearing age in oil palm is about -----years (3years)
3. Mention the stage of harvest in oil palm
4. FFB in oil palm stands for ----- (Fresh fruit bunches)
5. Oil palm FFB has to be processed within 24 hours of harvest Why?

LECTURE 20

CASHEW

(*Anacardium occidentale* L.), Family : Anacardiaceae (2n = 42)

Cashew in India

1. Status in the world: The cashew kernel of India is of best quality in the world. India is the largest producer and exporter of cashew in the world. India stands first in area and production in the world, Area = 37 % and Production = 42 % production. Indian cashew export: 63 per cent of global cashew trade

Annual export earnings from India is nearly 2500 crore rupees out of which nearly 50 per cent is from imported raw nuts. In general over Rs. 3000 crore is the export earnings by the export of over 1 LMT cashew kernel and CNSL

2. Productivity: National average is 835 kg per ha (i.e., around 5.50 kg per tree) and this is far less than the achievable level of 2000 kg per ha (i.e., around 12.50 kg per tree). Maharashtra state is having highest productivity of about 1500kg per ha (Mainly due to adoption of drip irrigation and mulching techniques) while productivity in Kerala has come down (850 kg per ha) mainly because of old plantations.

3. Employment: Cashew gives employment to five lakh people in plantations and factories.

4. Processing units: In India there are more than 1700 processing units. Requirement of raw nuts for these factories is about 10 to 12 Lakh Metric Tonnes (LMT) but domestic production in India is around 6 LMT. The deficit is imported from African and other countries viz.,

Origin and Distribution of cashew

Origin:

- ♣ South Eastern Brazil. (Tropical America – NE Brazil) The genus *Anacardium* must have originated in the Amazon region of Brazil.
- ♣ The word cashew is derived from Portuguese word “Caju” who introduced it into India during 16th Century. There are about 20 species of *Anacardium*.

Distribution of cashew

World:

World cashew production: In the world about 32 countries are growing cashews (Between 30°N to 30° S) African countries: Angola, Kenya, Madagascar, Mozambique, Nigeria, Tanzania, etc

North Central America: El Salvador, Honduras, South America, Brazil,

Asia: India, Vietnam, China, Indonesia, Malaysia, Philippines, Sri Lanka and Thailand,

Table: Major cashew producing countries in the world

	Area harvested (ha)	Yield (Kg/ha)	Production (tonnes)
Vietnam	340800	28110	958000
India	893000	7782	695000
Nigeria	330000	17598	580761
Côte d'Ivoire	660000	3733	246383
Brazil	758085	2908	220505
Indonesia	310000	4677	145000
Philippines	27428	40831	111993
United Republic of Tanzania	80000	9887	79100
Mozambique	60000	11307	67846
Guinea-Bissau	212000	3049	64653
Total	4103562		3350929

Distribution in India

- ♣ Area in India = 8.54 lakh ha
- ♣ Production: 5.50 lakh tones (LMT)
- ♣ Export earnings (2006-07): 2455 crore rupees by the export of 1.19 tones of cashew kernel.
- ♣ Productivity: Average Indian productivity is 865 kg/ha while highest in Maharashtra i.e 1500 kg/ ha
- ♣ Potential productivity: 3 tones per ha
- ♣ Highest area under cashew in India: AP

Area, Production & Productivity of Cashew nut in India

A - Area in '000 Ha.

P - Production in '000 MT.

APY - Average Productivity in Kg per hectare

STATE	2007-08			2008-09		
	A	P	APY	A	P	APY
Kerala	84	78	900	70	75	900
Karnataka	103	56	710	107	60	720
Goa	55	31	700	55	30	700
Maharashtra	167	210	1500	170	225	1500
Tamil Nadu	123	65	700	131	68	710
Andhra Pradesh	171	107	900	182	112	920
Orissa	131	90	860	137	95	865
West Bengal	10	10	1000	11	11	1000
Gujarat	4	4	1000	6	4	700
NE States	15	12	750	16	12	750
Others	5	2	500	8	3	460
T O T A L	868	665	860	893	695	900

In India it is cultivated mainly in the coastal regions i.e., East and West coast of India.

Recently (2008-09) the AP is top in area and MH in productivity of cashew

East Coast: Kerala, Karnataka, Goa and Maharashtra Major producing area

Eastern Coast: AP, Orissa, TN, WB, and Pondichery etc

Export earnings from India (2007-08)

More than 2500 crore INR

CNSL rate (2008) = Rs 26/kg

Soil and Climatic Requirements

Soil: Cashew being a hardy crop, it can be grown on a wide range of soils.

Avoid soils which are

Heavy, Water logged and Excessive alkaline and saline soils (Z^{1/4}Ä) as tap root will bend when reaching heavy soil.

Roots of cashew:

Cashew has

- 1) Tap root --- Penetrates deep into soil,
- 2) Extensive network of lateral root system: Because of deep tap root and network of both primary and secondary roots plant gets adequate nutrition and water even during the period of prolonged drought.

Rhizosphere of cashew :

Depth : 60 cm contains over 70 per cent of active roots

Surface spread : upto 2 m radius from the base.

Climate for cashew:

It is a sun loving tree and does not tolerate excessive shade. It cannot tolerate temperature above 45⁰C during fruit set and development stage. Cashew is a tropical crop, loving warm and humid /moist climate of tropics.

1) **Vicinity to the sea: Mainly because minimum temperature is high.** Cashew is a coastal tree (Particularly low land mainly because of low temperature range i.e., night temperature range of 13 to 18 ° C) and closeness of sea is a favourable factor for cashew though it comes up in other areas i.e., even at about 1000 km away from the sea coast in India, Tanzania, Brazil etc.

2) Latitude:

Hopkin's Bioclimatic law: Geographical co-ordinates (Latitude, Longitude and altitudes) influence flowering. For perennial trees flowering is influenced by these geographical co ordinates i.e., for every

- a) Every 400 feet altitude
- b) Every 1° Latitude and
- c) Every 5 ° Longitude (From West to East) there will be delay in flowering by four days.

Cashew comes up well between latitude of 25 ° N and 24° S.

3) **Altitude: lower is the altitude better will be the performance:** Many of the commercial plantations are up to an elevation of 600 -700 m. and **lower is the altitude better will be the performance.** There will be about three days delay in flowering for every 100 m altitude. At higher altitudes flowering and fruit setting is delayed i.e., delayed harvest than the coast. However, plantations are seen up to an elevations of 1000 m. asl.

4) **Temperature:** Minimum Temperature is most important:

A) Minimum temperature should not come down below 10°C during flowering period.

B) Maximum temperature of more than 35 °C during reproductive / flowering period cause nut drop in cashew (East coast). In cashew though cashew can adopt a wide range of temperature from 15 ° C to 45 °.

C) Best range of temperature in 19 °C to 35 ° C. Cashew is very sensitive to low temperature i.e., frost injury.

The meteorological factors like night temperature (<10°C) and day maximum temperature (>35°C) during the reproductive phase of cashew may not be conducive for better flowering and nut weight across the east coast.

5. Sunshine/ Phototropism: Cashew is a sun loving crop like coconut. It requires about 2000-2400 hr sunshine per year (i.e., > 6 hours per day). It requires about 1285 hr. sunshine in the flowering /fruit set period (Nov-March). In India sunshine recorded above 9 hours per day from Dec – May on the west coast during Flowering /Flushing and fruiting season.

Pest incidence vs sunshine: The major threat to cashew production across the west coast is the incidence of tea mosquito bug complex. It is, again, triggered by favourable weather.

Cloudy weather during flowering enhances tea mosquito infestation.

Question Bank

- 1.Cashew belongs to the family ----- (Anacardiaceae)
- 2.Write about the importance and scope of cashew cultivation in India
- 3.Cashew is originated from ----- (Brazil)
4. Write about the climatic requirement of cashew
5. Write about the distribution of cashew in India

LECTURE 21

CASHEW VARIETIES

Breeding achievements in cashew: Earlier cashew was primarily propagated for soil conservation and forestation. At present due to the effort of research 40 varieties have been released. Of these

25 varieties are from selection in the germplasm and

15 varieties are developed by the breeding technique of hybridization and selection.

Cashew Varieties - for Karnataka

There are many cashew varieties/selections/hybrids suitable for different agro climatic conditions.

Varieties recommended for Karnataka includes;

Table: Released varieties of Cashew nut for Cultivation in Karnataka .

Variety	Yield (Kg/tree)	Nut(g)	Shelling	Kernel wt(g)
Ullal (UASB Karnataka)				
1. Ullal-1 (8/46 Taliparamba, Kerala)	19(25)	6.6	30.7	2.15
2. Ullal-2 (3/67 Guntur, Andra)	18(25)	6.0	30.7	1.83
3. Ullal-3 (5/37 Manjari, Kerala)	15(20)	6.9	30.0	--
4. Ullal-4 (2/27 Tuni, Andra)	9.5	---	---	--
5. UN – 50(2/27 Neeleshwar, Kerala)	10.5	9.0	32.5	--
NRCC, PUTTUR (KARNATAKA)				
1. NRCC-1	8.8	9.2	28.6	--
2. NRCC-2	11.5	7.6	28.8	--

6) Chintamani Cashew -1: Recommended for Southern Dry region of Karnataka.

8) NRCC-1: From National Research Centre on Cashew, Puttur.

9) NRCC -2: From National Research Centre on Cashew, Puttur. It produces big sized nut i.e., nut weight of 9.20 g.

10) VENGURLA - 4

Mean nut yield / tree: 17.2 Kg

Nut weight : 7.7g

Shelling % : 31

Export grade : W210

11) VENGURLA - 7

Mean nut yield / tree: 18.5 Kg

Nut weight : 10g

Shelling % : 30.5

Export grade : W180

Varieties of Maharashtra

Among vengurla varieties V-4 is popular in Khanapur area of Karnataka.

V-1 is multiplied and not abandoned as it is an early flowering type

V-4 is popular in Belgaum District.

V-7 and V-8 are of bigger nut size.

V-8: Newly released variety with bigger nut size and apple size

Vengurla 1 to V-7, V-7 is having bigger sized nut.

Hybrids: V-3 to V-8 are hybrids

Varieties of Andhra Pradesh

Bapatla 1 to Bapatla -6 (BPP-6)

Varieties of Tamil Nadu

Vridachalam (VRI) – to VRI-4

Varieties of Kerala

Anakkayam -1, Madakkathara -1, Dhana (H-1608), Kanak (H-1598), Amrita, Priyanka (H-1591), Dharashree (H 3-17), Anagha (H8-17), Sulabha, Hybrid Dhara, **KGN -1** (i.e., K.G.

Nair (ex CEPC Secretary) -1 a dwarf cashew collected from Brazil which can be planted at 3 m x 3m spacing), etc

Priyanka and Anagha are from Annakayam research station.

Cashew varieties with bigger and bold nuts are UN-50 (i.e., 9.2 g), NRCC-2 (i.e., 9.2 g), Vengurla -7 (i.e., 10.0 g), Anagha (i.e., 10.0 g), Priyanka (i.e., 10.2 g), Akshaya.

Propagation in cashew

1) Seedling propagation: Though it is commonly practiced method of cashew propagation, it is not encouraged due to high proportion of cross pollination leading to considerable variability among seedling progenies.

Clonal / Vegetative propagation: Cashew is amenable for vegetative propagation by different methods.

- Grafting
- Epicotyl
- Soft wood
- Veneer
- Side grafting
- Top working etc
- Budding and
- Layering i.e., air layering and Mound layering/ Stool layering (Stooling) etc.

Soft wood grafting: Among the vegetative propagation methods soft wood grafting is more successful in most of the cashew growing areas. It is similar to epicotyl method of grafting but differ only with respect to age of the seedlings (root stocks) used for multiplication. In soft wood grafting 30 -40 days old seedlings with 1 to 2 pairs of leaves are retained on root stocks while grafting. However, usually soft portion of the seedlings at 15 -20 cm from ground level is availed for grafting.

For grafting 10-12 cm long pencil thick scion from current seasons growth should be selected and precured. Precuring is done by clipping off the lamina leaving the petiole intact on the shoots. Within few days these petioles drop-off indicating the shoots are getting cured. Due to storage of food material the shoots get thickened and the terminal bud appears swollen. This swollen condition indicates that shoots are ready for separation from the tree. Precuring is done to increase the meristematic activity in the auxiliary and terminal buds.

Wedge technique is used for grafting. Two pairs of bottom leaves are retained on the stock and the stock is decapitated 5cm above the second pair of leaves and a vertical incision, along the length of the stump to 3.75cm from the top of the stock is made. The scion is prepared like a wedge. It is inserted into the stock and tied with polythene strip of 1.5cm width and 30cm length of 100 gauge. To create a humid atmosphere around the scion bud, polythene caps of 20 x 2.5cm size of 100 gauge thickness is provided for 15-20 days till the buds sprout.

The grafts are kept under shade or in a mist chamber preferably since humidity and temperature can be controlled. Application of NPK @ 150:20:100 ppm supplied through irrigation water helps in better survival of grafts. When the buds are sprouted remove polythene caps and grafts are shifted to open place. The successful graft shows signs of growth within 3-4 weeks after grafting. The success percentage in soft wood grafting is more during March- September under Kerala conditions.

Planting and management of grafts in the main field

The softwood grafts are planted in pits of 50 cm³ with topsoil and 5-10 kg of compost or dried cow dung per pit after removing the polythene bags during June- July. Care should be taken while planting to see that the graft union is 2.5cm above the ground level. The polythene tape is to be carefully cut and removed. Staking should be done immediately after planting to protect the grafts from damage.

Top working in cashew,

The technique of top working was first standardized at ARS Ullal. It is for the rejuvenation of uneconomical cashew trees. It involves following steps;

1. **Selection of trees:** The selected cashew for rejuvenation should be
 - a. **Low yielding trees:** Trees yielding less than 2 kg per tree are selected.
 - b. **Trees bearing small sized nuts:** Trees producing nuts which weigh less than 200 nuts per kg of raw nut. (i.e., less than 5 g per nut)
 - c. **Trees which are highly susceptible to tea mosquito attack.**
 - d. **Age:** Age between 10 to 25 years are suitable.
 - e. **Trees free from stem borer infestation.**

2. Beheading of trees:

- a. **Time and season of beheading :** December to February
- b. **Remove branches :**
- c. **Stumping: Cutting** stump at 0.50 m to 0.75 m above ground level with saw to avoid bark splitting.
- d. Smearing cut portion : Smear the cut portion with BM – 10 % paste or cow dung slurry and red soil.
- e. **Basin rectification :** Prepare a basin of 1.50 m radius
- f. **Plant protection :** Paste sevin dust + Blitox (50 g sevin dust + 50 g blitox per liter of water)
- g. **Provide shade.**

3. Sprouting of beheaded trees:

- a) **Sprouting:** New sprouts appear in 30 to 40 days after beheading.
- b) **Remove shade**
- c) **Thinning:** Retain 10 to 12 healthy shoots/sprouts for grafting and remove others.
- d) Periodical removal of new sprouts to facilitate the growth of selected sprouts.

4. Selection of Scions:

- a. Select scions from high yielding varieties
- b. Pencil thick and 12 to 15 cm long scion stick with a sprouted bud should be selected from shoots of 3 to 4 months growth.
- c. Preconditioning: Remove all the leaves 7 to 8 days before grafting.
- d. Fresh scion is always preferred for better success.

5. Grafting:

- a. Select 10 to 12 sprouts for grafting.
- b. Cut the sprout 5 to 6 cm from the top and split it in the middle to 3 – 4 cm depth with the help of a knife.
- c. Technique of grafting : Wedge grafting
- d. Select the scion of the same thickness and give a cut to form a wedge or “V” shape.
- e. Insert the scion: Firmly tie with the help of polythene strip.
- f. Cover the grafted portion with the help of polythene bags./ caps

6. After care:

- a) Sprouting in 10 to 15 days. About 5 to 6 successful grafts are sufficient per tree.
- b) Remove excess and unsuccessful shoots.

Advantages of top working

- I. Vigorous growth: Top worked trees are vigorous in growth, because of well established root system.
- II. Top worked trees starts yielding from second year itself after rejuvenation.
- III. Higher average yield and high yield during their life time.
 - 2nd year = 4kg
 - 3rd year = 6 kg
 - 4th year = 8 kg per tree when compared to 2 kg per tree in old plantation (Before top working / rejuvenation) which is 3-4 times more than that of earlier yields of 2 kg per tree.
- IV. Cost involved for top working could be recovered from the sale of wood in the first year itself.
- V. Higher nut production could be seen beyond fifth year of the top worked trees,
- VI. We can have different varieties of cashew on a single tree

Question Bank

- 1. Mention cashew varieties which produces bigger size nuts
- 2. Explain the commercial method of vegetative propagation in cashew
- 3. Narrate top working in cashew
- 4. Mention the varieties developed by NRC cashew Puttur
- 5. List out the advantages of top working

LECTURE 22

ESTABLISHMENT AND MANAGEMENT OF PLANTATION

Establishment and management of plantation

Table: Calendar of operation in cashew. (Under west coast of Karnataka)

Sl. No.	Month	Operation
1	June - July	Planting season
2	August – October- May	No operation
3	September	Weeding, Soil working and fertilizer application
4	November December and January	Plant protection with insecticide for control of tea mosquito bug (A fungicide if anthracnose problem is anticipated)
5	February, March and April	Harvesting and collection of nuts

Planting time: With the onset of monsoon.

Planting :

Pit size : 60 cm x 60 cm x 60 cm

Spacing : 8 m x 8 m (156 plants /ha). At closer spacing (say 2m x2m =2500 plants per ha) overlapping branches (Interlocked branches causes shading /mutual shading leading to reduced yield).

Spacing in cashew may be adjusted based on

- 1) System of planting
- 2) Moisture status of soil
- 3) Fertility status of soil
- 4) Variety and
- 5) Planting material used etc.

High Density Planting in Cashew

Experiments were carried out at NRCC Puttur and in AICRP on cashew centers in different parts of the country with plant population ranging from 156 to 2500 trees per ha in order to study the effect of high density planting in cashew towards enhancing productivity. Present recommendation of plant density in cashew varies from 156 plants (8 m x 8 m) to 200 plants per ha.

Spacing for High density plantations (Depending upon agroclimatic conditions)

Set – I (After thinning spacing of 8m x 8 m will be maintained)

4 m x 4 m or

8 m x 4 m or

7 m x 4 m or

Set – II (After thinning spacing of 8m x 8 m or 10 m x 10m or 6 m x 8 m will be maintained)

5 m x 5 m or

6 m x 6 m or with a population varying from 312 to 624 plants per ha

Poor soils are more suitable for HDP due to poor canopy expansion.

Age /period of thinning of plants: After 7 to 10 years depending on the spread of canopy.

Spacing maintenance after thinning

Set – I = 8 m x 8m

Set – II 8 m x 8m or 10 m x 10 m or 6m x 8 m

Advantages of HDP:

1. Higher yield per ha during initial years (There will be 625 tree per ha in 4 m x 4 m spacing compared to only 156 tree in 8 m x 8m spacing)
2. Fuel wood: due to thinning of plants.
3. Weed control.
4. Soil conservation due to canopy coverage.

Varieties suited: Dwarf varieties with compact branches are well suited.

Eg. Anakkayam -1 and Dhana.

Manuring

Manures and fertilizers promote growth of the plants and advance the onset of flowering in young trees

FYM: Application of 10-15 kg of farm yard manure or compost per plant is beneficial

Biomass available in cashew for recycling : 5 to 6 tonnes per ha about 15 to 20 kg leafy biomass per tree is available in cashew

Inputs per ha

1. Planting material per ha. = 155 when spaced at 8 m X 8 m apart.
2. Film or Compost = 2.5 tonnes per ha.
3. Fertilizers (g/plant)

Year	May - June			Sept - October		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
I	50	40	--	50	40	--
II	100	40	30	100	40	30
III	200	60	60	200	60	60
IV	250	60	60	250	60	60

Annual dose for adult cashew (4th year and above) = 500(1.10 kg Urea): 125 g (625 g R/P): 125 gK (208 g MOP) NPK per plant per year.

Application schedule: The ideal period for fertilizer application is immediately after the cessation of heavy rains and with available soil moisture. During the 1st, 2nd and 3rd year of planting 1/3rd, 2/3rd and full doze of fertilizers should be applied and 3rd year onwards full quantity is to be applied.

Method of application:

Apply in basin of 15 cm deep. Prepare trenches of 2 to 3 m radius around the tree trunk.

For more efficient use of fertilisers the root distribution of cashew should be considered. It depends on age of the tree, type of planting material, the soil environment, level of nutrition, irrigation etc. According to Wahid et al (1989) and Salam et al (1995) the lateral spread is 3-4 m and vertical depth is 60-100cm. But cashew is mostly a surface feeder.

Method of fertiliser application

For adult trees apply fertilisers within **a radial distance of 2-3 m leaving half a meter from the tree trunk or in narrow trenches of 15 cm deep** and covered with soil within the radial limit. For young trees, fertilisers can be broadcast and incorporated over the entire tree basin (10cm deep) within the canopy area.

An extensive review on nutrient management is given by Salam (2002).

Irrigation in cashew:

Initial years of establishment: In the initial stages of establishment (seedling stage) cashew needs irrigation in summer especially in sandy soils. However, we have to provide drainage in places of water stagnation.

Drip irrigation with four drippers at 1 m away from the tree base **@80l/tree once in 4 days from the second fortnight of December to the end of March coinciding with the flowering season** resulted in significantly higher yield as compared to lower levels of irrigation or without irrigation (Samuel, 2002).

Experiments at DCR Puttur has shown that,

Irrigation during January to March has doubled yield in yielding cashew plantation

Note: However, by irrigation flowering period in cashew is extended. To have shorter flowering period (convenient for harvest and TMB management) we have to with hold irrigation before flowering.

PRUNING OF ADULT CASHEW TREES

Limb pruning is suggested in cashew (At Puttur conditions)

Height of beheading: 1 m of stem

Season Beheading: May – June (Before the end of July)

In general **season of pruning is May to September.**

Kolar conditions = August – Sept'

Plant Protection limb pruning: BM -1 % may be pasted. However, Pasting with cow dung slurry to protect it from pest and disease entry and also promotes growth

Limb pruning increases cashew yield by flushing

Question Bank

1. Write about the calendar of operations in cashew
2. Narrate high density planting in cashew
3. Write about the manuring and method of fertilizer application in cashew
4. Harvesting season in cashew is during ----- months (January to April)
5. What are the advantages of High density planting?

LECTURE 23

PLANT PROTECTION IN CASHEW

Pests in cashew: Tea mosquito, stem borer, thrips, leaf minor and leaf blossom webber are important pests of cashew. Of these, tea mosquito and stem borer causes economical damage in cashew.

- 1) Tea mosquito bug : *Helopeltis antonii*
- 2) Stem and root borer: *Plocaederus ferrugineus* L.
- 3) Mealy bug
- 4) Flower Thrips
- 5) Leaf minor :
- 6) Leaf and blossom webber :

Diseases in cashew

1. Dieback or pink disease
2. Leaf spots
3. Powdery mildew
4. Root and seedling rot
5. *Fruit rot*
6. *Cashew decline*
7. Inflorescence blight
8. Leaf and nut blight disease
9. Anthracnose
10. Cashew wilt

Tea mosquito bug (*Helopeltis antonii* s.) ,

Season of incidence: Flushing season. Severe usually at the time of emergence of new flushes and panicles i.e., when trees are in full bloom. (October to January)

However, in general it attacks the tree in all the seasons during flushing, flowering and fruit setting period but the peak period of infestation is from October to March.

Rainy season: Minimum activity and lives on alternate hosts

Management of TMB

1) **Habitat management:** Avoid population build up in other host plants like Guava, neem, Drumstick Cocoa, Pepper, cotton, Singapore cherry etc

2) **Choice of varieties:** At present resistant or tolerant varieties are not available. However, variety Bhaskar (Goa 11/6) is less susceptible. It is easy to manage TMB if flushing is of short period compared to extended period.

Early bearing varieties are most susceptible and Late season varieties (including mid season varieties escapes severe infestation of TMB

3) **Bio control including botanicals:** Botanicals including Pongamia oil, neem oil etc were found to be non effective

4) **Chemical control:** Four sprays at an interval of 2 to 3 weeks from middle October coinciding with new flush.

New flush = October – November

New inflorescence = Dec to January

1) Cashew stem and root borer (*Plocaederus ferrugineus L.*)

A dreaded enemy of cashew leading to death of the tree this pest is more severe in neglected cashew plantation.

Methods of damage = Grubs comes out and bores into the bark and feed on the epidermal and vascular tissues = Tunneling of stem and roots

Symptoms

- 1) Presence of small holes in the collar region
- 2) Gummosis : Oozing of gum
- 3) Frass extrusion : Extrusion of chewed up fibres and excreta
- 4) Bark discolouration
- 5) Foliar Yellowing : Yellowing and shedding leaves
- 6) Dreaded enemy : Death of tree

Management of CSRB:

- 1) Identification in the initial stage of infestation: Do not treat trees which are in the stage of showing yellowing even in the monsoon. Yellowing is the stage before the death of cashew.
- 2) Phytosanitation: By the removal of dead trees and trees which are showing particularly at the end of monsoon.
 - a) **Yellowing:** complete yellowing due to CSRB infestation
 - b) **Boring:** Showing more than 50 per cent damage to the bole :
- 3) Mechanical removal of the immature stages of the pest : The grub has six instars and remove the pest in the initial stage of development to avoid damage of tree. While removing the grub damage the bark to the minimum extent.
- 4) **Treatment/ Swabbing : Swabbing or Pasting** the damaged portion with mixture of Carbaryl 50 gm (50%) and copper Oxochloride (25 gm) in one liter of water give effective control. We can also use Chloropyriphos or lindane pasting

Preventive treatment: Swabbing with Coal tar + Kerosene (1: 2) to a height of 1 m trunk four times in year.

Harvesting, yield, processing and grading in cashew

Pre flowering age in cashew: 3 to 4 years

Full bearing age = 10 to 12 years

Economic life = over 50 years (35 to 40 years and even upto 60 years).

Stage of harvesting: Fully mature nuts, Cashewnuts when fully mature look greyish brown.

Method of harvesting

- a) Collection of fallen nuts: It is better to pick the fallen nuts because there is a possibility of harvesting immature nuts which leads to poor quality kernel during processing.
- b) Periodical plucking of apple : For preparation of cashew apple products one has to pluck the fruits from the tree. If it is fully mature the fruit just drops.

Yield in cashew: 10 to 15 kg per raw nuts tree (Apple yield is 8 to 10 times than that of seed yield)

Processing in cashew nut: Harvested nuts will be dried for 2 to 3 days

Nuts after drying can be stored in gunny bags well protected from rodents and stacked on a platform above the ground level leaving space on all the sides of the room.

Well dried raw nuts (moisture content 8 to 9%) could be **stored upto one year** without any quality deterioration

Processing in cashew refers to the recovery of kernel from mature nuts by manual or mechanical means.

Mechanical processing involves

Moisture conditioning (Moisture content in the nut is increased to 15 to 25 %) === Roasting
===== Shelling ===== Peeling (Removal of seed coat or testa) -drying === Grading =====
Packing (Vacuum packing extends shelf life in cashew by additional one year) = Marketing

Roasting: Makes shell brittle

Methods of roasting

- 1) Drum roasting: Results in high percentage of wholes . Dis advantage here is loss of CNSL.
- 2) Oil bath roasting: Shell gets heated and shell wall gets separated releasing oil into bath. i.e. CNSL is recovered.
- 3) Steam boiling
Shell contains 35 % CNSL and CNSL contains anacardiac acid to an extent of 90 %.

CASHEW NUT SHELL LIQUID - A versatile Industrial Raw Material

1. This raw material is used for a number of polymer based industries like paints and varnishes, resins, industrial and decorative laminates break lining and rubber compounding resins. (For more details contact Regional Research Laboratory, Trivandrum, Kerala.
2. The nut has a shell of about 1/8 inch thickness inside which is a soft honeycomb structure containing a dark reddish brown viscous liquid. It is known as cashew nut shell liquid, which is present in the pericarp of the cashewnut.
3. In India annual production of CNSL will be around 15,000 tonnes where as the potentiality available is around 45,000 tonnes and the world production of CNSL will be around 1.25 lakh tones.

GRADING IN CASHEW

Basis of grading: Based on counts i.e., number of kernels per pound i.e., 453.5 g

CEPC (Cashew Export Promotion confirms grade specification and recognizes 24 different grades of kernels

I	Main grades	Wholes – Good, big sized kernel (Export quality) Eg. W-180
2	Second grades	Whole – good, medium sized kernels (Export quality)
3	Third grades	Halved and broken (Sold locally)
4	Fourth grade	Rejected and spoiled (Sold locally)

Grades of Whole kernels in cashew (Wholes are the kernels which have no split). These are again separated in to 6 grades as

I	Grade	Whole Kernels per lb	
2	W-180		Best grade in the world cashew market
3	W-210	200-210	
4	W-240	220-240	
5	W-280	260 – 280	
6	W-320	300-320	Rates in the world market are based on this grade
7	W-400	350-400	
8	W-430	400-430	

Question Bank

1. List out the major pests of cashew
2. Suggest management practices for tea mosquito bug
3. ----- pest kills cashew tree (Cashew stem and root borer)
4. Cashew is harvested at ----- stage of maturity (Fully mature nuts)
5. CNSL stand for (Cashewnut Shell Liquid)
6. Write about grading of cashew kernel

LECTURE 24

RUBBER

Rubber /Para rubber

(*Heave brasilensis Muel-Arg*)

Fam: Euphorbiaceae

Origin and distribution,

Origin: Amazon River basin of Southern America. This crop was introduced to South Asia through Kew garden in the U.K in the late 1970's. Now it is grown in tropical regions of Asia, Africa and America.

Distribution of rubber

World:

1.

	Area harvested (ha)	Yield (kg/ha)	Production (tonnes)
Thailand	1856070	16649	3090280
Indonesia	2941360	9484	2789850
Malaysia	1237000	6928	857019
India	450000	18240	820800
Vietnam	421600	17165	723700
China	600000	10314	618866
Philippines	128300	30472	390962
Nigeria	345000	4202	145000
Sri Lanka	124000	10967	136000
Brazil	128900	9850	126973
Total	8821006		10221285

Total rubber production in the world (1996) is 63.20 lakh tonnes

India ranks fifth and fourth in total area and production of natural rubber. In productivity India ranks first in the world.

India:

Area : 5.33 lakh ha

Production : 5.44 lakh tonnes

India ranks first in the world with regards to the productivity of natural rubber i.e., 1,503 kg per ha.

States:

Kerala,

Tamil Nadu

Karnataka

These three states altogether accounts to 98 per cent of total produce of India.

Climate and soil

Climate:

Tropical climate = Tree of warm humid climate.

Temperature: 21° to 35 ° C

Altitude : upto 500 m asl

Sunshine : It is a sun-loving tree requiring 6 hours of sunshine per day throughout the year. i.e., about 200 hours per year.

Rainfall: Not less than 200 cm.

Soil:

Depth: Minimum of 125 cm depth.

Slope : A gentle slope is needed.

p^H : 5.5 to 6.5,

Propagation:

Seed Propagation: For nursery planting seeds are germinated in shaded beds of friable soils, sand or coir dust. Germinated seeds are transplanted into shaded nurseries at spacing depending on the type of plant required. Seed germination will be completed in about 3 weeks. Seeds start germinating with in 6 - 10 days of sowing.

Clonal seeds: Sexual progeny of budded clones is known as clonal seed. Seed garden progeny is probably a better name. As clonal seedlings are more variable than budded rubber their average yield is less. It is desirable to select for vigor in the nursery and in the field

and later for yield in the early years of bearing. Legitimate seeds may be produced by hand pollination between selected clones.

Budding: Popular method of vegetative propagation in rubber is by bud grafting using buds of selected mother trees. Nursery seedling can be bud grafted when they attain a girth of a pencil above the collar. Budded stocks are ready to be stumped about 4 weeks after budding. they are cut 10 - 15 cm above the bud patch and the stumps are pulled out and transplanted in the main field. Green budding with buds stripped from green shoots is also practiced.

Rubber is almost entirely propagated through bud grafting of modern high – yielding clones. Bud grafting is done on the seedlings when they are 2-8 months old using green or brown dormant bud patch collected from selected scion clones.

Depending on the colour and age of the buds two types of budding are recognized.

1) Brown budding: Here bud wood is of about one year old. Brown buds are collected from bud wood of one year old and grafted on to the seedlings that are of about 10 months old.

Stock plants: Vigorously growing 10 months of more aged plants having a girth of about 7.5 cm at the base are ideal for budding.

Scion / bud wood: Buds from selected scion plants having about one year growth from the axils of fallen leaves are generally used. Normally 1-2 m of bud wood can be obtained from a bud wood shoot of one years growth from which about 20 buds can be obtained.

2) Green budding: Here both stock plant and scion used for green budding are young. Seedlings of 2 to 8 months old (with green stem) are used as stocks to graft green buds collected from leaf axils of bud wood that is 6 to 8 weeks (1 ½ to 2 months old).

Scion / bud wood = from bud shoots of 6 to 8 weeks growth.

Stock plant = Vigourous seedlings of about 2 to 8 months age.

Age of stock → Vigorous seedlings of 2-to 8 month's age with girth of about 2.5 cm and

Brown bark up to a height of about 15 cm

Scion → Green buds taken from bud shoots of 6 – 8 week growth i.e. buds seen in the axil of scale leaves.

Sl No.	Particulars	Brown budding	Green budding
1.	Age of stock	> 10 months old	2 to 8 months old vigorous seedlings
2	Maturity or age of scion or bud wood.	One year	6 to 8 weeks
3	Colour of bud wood	Brown and buds are in axils of fallen leaves.	Green and buds are in axils, when leaves are still attached and functional.

Classification of rubber clones: In rubber clones are broadly classified into three categories based on the methods adopted for the development of mother trees.

1. Primary clones: When mother trees are selected from existing seedling populations of unknown parentage and are multiplied vegetatively. Eg: Tjir -1(Tjirandji -1 of Indonesia), G.T-1 (Godng Tapen of Indonesi) , G.I -1(Glenshiel-1 of Malaysia) and PB-86.

2. Secondary clones: When the mother trees are evolved by cross pollination (hand pollination) between two primary clones and are then multiplied vegetatively, they are known as secondary clones.

Eg: 1) RRIM – 600 = TJIR –1 x PB – 86 and

2) PRIM - 628 = TJIR –1 x PRIM – 527

3. Tertiary clones : Are produced by controlled pollination of two existing clones, but they differ from secondary clones in that at least one of parents or both the parents are of secondary clones.

Eg: RRIM – 703 = RRIM – 600 x RRIM –500.

Table: Clones developed by RRII for cultivation in South India

Sl. No	Name	Parents	Important traits
A.	Primary clones		
1	TJIR –1	-	Indonesian clone yield = 930 kg per ha per year
2	G.T –1	-	Indonesian clone, Yield =1360 kg per ha per year
3	GI-1	-	Malaysian clone, Yield = 1130 kg per ha per year. Drought tolerant

4	PB- 86	-	Malaysian clone, Yield = 1130 kg per ha per year.
B	<u>Secondary clones</u>		
1	RRIM – 600	Tjir –1 x PB – 86	Developed by RRIM, Yield = 1317 kg/ha
2	RRIM – 628	TJIR – 1 x RRIM –527	Yield = 1051 kg/ha/yr
C	<u>Tertiary clones</u>		
1	RRIM – 703	RRIM- 600 x RRIM – 500	Yield = 1725 kg /ha/yr

Polyclonal seedlings in rubber

All desirable characters viz., high latex content, drought resistance etc may not be available in a single clone. Hence, it may not be wise to adopt a single clone for cultivation in large areas, because if disease or pest epidemic occurs the entire plantation may be wiped out. Therefore to get the benefits of mixed clones in a population, poly clonal seed gardens are being established by blending different clones. The hybrid RRII –105, is the highest yielding in the world. It has become very popular, occupying 80 per cent of the area under rubber. Its average yield is 2.400 kg /ha/year. Superior clones numbering 3 to 6 are planted in an isolated area and allowed for natural open pollination. For prevention of pollen contamination from rubber trees of neighbouring area an isolation belt of 100 m width is provided all around the seed plantation.

Polyclonal seed families generally give rise to seedlings of good vigour and growth. In olden days monoclonal seeds of single selected mother clones such as Tjir –1, not contaminated by crossing with seedling rubber or undesirable male parent clones had been extensively used as improved plant materials.

Poly clonal seeds are easier to establish and maintain when compared to buddings. The trunk of the seedlings are much larger than those of budded trees.

Table: Differences between polyclonal seeds and buddings of rubber;

Sl. No.	Features	Polyclonal seeds	Buddings
1	Establishment and maintenance	Easier	Comparatively needs more care
2	Trunk size	Larger	Comparatively of less

			diameter
3	Susceptibility to wind damage and diseases	Less	More
4	General yield level	Low (1200 to 1300 kg /ha/year)	High (1200 to 1700 kg per ha per year)

General yield levels of polyclonal seedlings are much lower than selected modern clones (buddings). However, selection based on initial vigour, high initial planting density in the main field and subsequent judicious thinning of weaklings and poor yielders in a phased manner is suggested to maintain the higher level of productivity.

Planting and after care

Preparation of land: All preparations should be finished before planting season i.e., June.

1) Clearing:



New areas



Old plantation: Old trees may be slaughter tapped.

2) Lining:

- ❖ Flat/Slightly undulated areas: Square planting or rectangular planting is followed by making lines in East – West direction to maximize sun light interception.
- ❖ Hilly areas with moderate (10 – 20 %) slope : Contour planting is suggested by marking across the slope.
- ❖ In hilly areas with steep slopes (> 20 % slope): Terracing is resorted.

Spacing/Planting distances

Sl .No.	Situation/Planting method	Spacing (m)	Plants per ha
1	Hilly areas	6.7 x 3.4 m	445
2	Flat areas- Square system	4.9 x 4.9	420
3	Triangular system	4.9 x 4.9	470

Pit size: It varies from 75 cm to 90 cm, depending on ;

- ▶ soil type = Hard soil go for wider pits
- ▶ Type of planting materials = Stumped buddings wider and larger pits, and in germinated seeds go for smaller pits.

After care:

Manuring in rubber:

For rubber trees under tapping (Usually above 7 years of age)

Recommendation:

Apply 12: 6: 6 NPK grade mixture at the rate of 400 kg per ha per year in two splits i.e.,

- ▶ April – May and
- ▶ September – October is recommended.

P₂O₅ has to be applied to rubber in the form of rock phosphate.

Method of Application

Fertilisers should be applied in square or rectangular patches in between rows, each patch serving four trees. Once the canopy of the plants closes, say, 5 to 6 years after planting, light forking to incorporate the fertilisers into the top soil is necessary. In areas where the legume ground cover is present or where the legume cover has died out leaving a thick mulch, it is enough to broadcast the fertilisers between two rows of rubber trees. Deep pocket placement of fertilisers and application too close to the base of the trees should be avoided.

Cover cropping:

It is always suggested to maintain the ground cover in rubber plantation in view of maintenance of soil as a permanent productive asset. Cover crops which can be grown in rubber plantations are;

1) *Pueraria phaseoloides* : Features A popular cover crop in India

- ▶ 1) Vigorous twiner and creeper that can be propagated by seeds and cuttings,
- ▶ 2) Can stand strong sun
- ▶ 3) Smothers weeds

Seed rate: 3 to 4.50 kg per ha.

Other cover crops includes

2) *Calopogonium muconoides* : A twiner and creeper and dies off during dry months.

3) *Centrosema pubescens* : Climber and can be grown in shade. However, it can not be grown under wet conditions.

Mulching:

Bases of young rubber plants must be weeded cleanly to avoid weed competition.

- Mulching with
- dry leaves,
- Water weed (*Salvinia* spp),
- Grass cuttings,
- Cover crop loppings etc

Around the plant is recommended to prevent soil degradation due to severe climatic conditions.

Aquatic weed = *Salvinia* spp (African payal) is spreading as a menace in the water ways and can be applied @ 5 kg per m² as sun dried material.

Season of mulching: After monsoon i.e., November

Weed control in rubber:

Until cover crops is established regular weeding is necessary. About 4 to 5 rounds of hand weeding are required during first 2 years. Once the cover crops are established or after the canopy has closed there is a little weed growth.

Question Bank

1. Botanical name of rubber is ----- (*Hevea brasiliensis*)
2. Mention the major rubber producing countries in the world
3. Narrate about vegetative propagation in rubber by budding
4. Write about rubber varieties
5. Write a note on polyclonal seedling in rubber

LECTURE 25

PLANT PROTECTION IN RUBBER

DISEASES:

(1) Abnormal leaf fall (*Phytophthora palmivora*): Infected leaves fall in large number prematurely.

Control: Spray Bordeaux mixture (1%) as prophylactic measure, prior to the onset of south west monsoon.

(2) Powdery mildew (*Oidium haveae*): Ashy coating noticed on tender leaves.

Control: Dusting sulphur @ 10 - 15 kg/ha. 3 to 6 times at 10 - 15 days intervals.

Pests:

1) **Scale insects (*Saissetia nigra*):** Severely affected portion dry up and die due sucking of sap from leaflets, petioles and tender shoot portions.

Control: Spray melathion at 0.05% concentration.

2) **Mealy bug (*Perrisiana virgata*):** Severely affected portion dry up and die. Damage is similar to scale insects.

Control: Spray melathion at 0.05% concentration or fish oil or soap water (Neem soap).

Non parasitic maladies:

Brown bast – Taping panel dryness (TPD)

Cause: A physiological disorder, mainly due to intensive tapping. High yielding clones are more vulnerable.

Symptoms: Partial drying up of tapping cut (initial symptom) with the outer latex vessel drying up first (No production of latex).

Light brown discoloration of the attacked portion (Hence TPD is also known as brown bast)

Tumors can be seen on the panel area. Drying up entirely and cessation of latex flow.

Control:

- 1) Remove affected tissues and
- 2) Rest the trees without tapping from 3 to 12 months,
- 3) Low frequency tapping is also recommended and
- 4) Proper manuring

Question Bank

- 1.----- and ----- are two major diseases in rubber (Abnormal leaf fall And Powdery mildew)
2. Mention the control measure for abnormal fall disease in rubber
3. How do you control powdery mildew in rubber?
4. Mention major pest on rubber
5. Give the symptoms of brown blast disorder in rubber and suggest control measures

LECTURE 26

HARVESTING AND YIELD

Rubber trees attain tapping age at about 7 years.

Tapping: Latex is obtained from the bark of the rubber tree by tapping, tapping is the process of controlled wounding during which thin shavings of the bark are removed to induce the flow of latex. The number of latex vessels increases towards the cambium. Tapping cuts extend to half the circumference of the tree (half spiral) and slope down to the right.

Standard of Tappability and Height of Opening

Budded plants are regarded as tappable when they attain a girth of 50 cm at a height of 125 cm from the bud union. In seedlings, the first opening for tapping is recommended at a height of 50 cm when the girth is 55 cm. If opening at a higher level is preferred, the seedling trees can be opened at a height of 90 cm when the girth at that level is 50 cm. In a budded tree, subsequent panels are also opened at the same height i.e., 125 cm. The height specified for opening subsequent panels on a seedling tree is 100 cm.

It will be generally economic to begin tapping when 70 per cent of the trees in the selected area attain the standard girth. In the traditional region it takes an average of seven years to reach this state. Planting of advanced materials like polybag plants reduce the immaturity period.

In India, the best period to open new areas for tapping is March-April. The trees that are left behind during the season for want of sufficient girth may be considered for opening in September.

Marking

Panels are marked on the trees selected for tapping, using a template and marking knife, parallel to the contour terrace or planting line to facilitate efficient tapping operation. The template is made of a strip of flexible metal, preferably GI sheet (of low carbon content). The width of template will depend on tapping frequency. i.e. under d/2 tapping 23 cm, d/3 - 17 cm d/4 - 15 cm and d/7 - 13 cm. Separate templates are required for seedlings and buddings and should be made in such a way that when used to mark, the slope of the cut should be 25° for seedlings and 30° for buddings.

After deciding the position of the panel, a vertical line, called front channel line, is drawn. On this line, the opening height is marked. Since half spiral tapping is the standard, the half circumference of the tree at the opening height is determined using a measuring tape or string and marked on the back. Another vertical line, called back channel line, is marked on the half spiral point above the opening height. With the aid of the template placed between

these two lines, at the opening height, ensuring a high left to low right, the line for tapping cut and a few guidelines are marked through the grooves. The vertical front end of the template should be kept on the front channel of the tree, parallel to it and the free end of the template is wound on the trunk towards the left side. After marking the guidelines, spout and cup hanger are fixed. The marking should be repeated annually.

Slope and Direction of Tapping Cut

The tapping cut of the budded trees should have a slope of about 30° to the horizontal. For seedling trees the cuts need to have a slope of only about 25° , since the bark is fairly thick. A very steep cut leads to wastage of bark when tapping reaches the base of the tree and too flat a cut leads to overflow of latex. The slope should be marked, preferably annually, using appropriate template.

The latex vessels in the bark run at an angle of $3-5^{\circ}$ to the right and therefore a cut from high left to low right will open greater number of latex vessels.

Tapping Depth, Bark Consumption and Bark Renewal

The best yield is obtained by tapping to a depth of less than one millimetre close to the cambium since more latex vessels are concentrated near the cambium. Shallow tapping results in considerable loss of crop. To obtain optimum yield, at the time of tapping care should be taken not to injure the cambium. However, minor tapping wounds which will heal in due course need not be considered as serious in the case of medium and low yielding clones.

To restart flow from a tapping cut in a subsequent tapping, all that is needed is to cut a thin shaving of the bark along with which the plugs of coagulated latex are also removed. Latex flow ceases when latex gets coagulated, clogging the cut ends of the latex vessels in turn with minute plugs of coagulated latex.

The rate of bark consumption will depend much on the skill of the tapper. For obtaining optimum yield, it is preferable to consume about 20-23 cm of bark annually on 1/2S d/2 system without rest period. However removing bark shaving thicker than what is necessary does not increase the latex yield but only wastes the bark.

Bark regeneration is brought about by the activity of the cambium. The rate and extent of renewal are dependent on the inherent genetic characters of the planting materials, fertility of the soil, climatic conditions, tapping system and intensity, planting density, and disease incidence.

Time of Tapping and Tapping Task

It is necessary to commence tapping early in the morning, since late tapping will reduce the exudation of latex due to increased transpiration by the trees leading to lower turgor pressure in latex vessels. Such reduction is more marked in the summer months. For pre-dawn tapping, headlights are used.

The number of trees allotted to a tapper for a day's tapping is known as tapping task. Task size is fixed on the basis of stand of trees per ha and topography of land. Normal tapping task in India varies from 300 to 400 trees. Task size is reduced when double cut or other intensive systems are adopted.

Economical life: About 40 years

After the completion of economical life go for slaughter tapping.

Yield:

In south India the annual yield of rubber is about 375 kg per hectore per annum from the seedlings, whereas budded plantations yield 900 to 1000 kg of rubber per ha. Average latex yield of 1000 to 2000 kg per ha (even some times it ranges from 850 kg to 2500 kg)

Market rate: Rs 40 to 50 per kg.

Tapping and processing:

Latex is a milky white dispersion of rubber in water which is harvested by the process of tapping.

Containers: Coconut shell,

Polythene cups. These containers are generally used to collect latex in Indian estates. Collected latex is later transferred to clean buckets two or three hours after tapping.

Latex coagulum rubber / Field coagulum includes;

Normally 15 to 25 per cent of total crop constitutes tree lace, shell scrap and earth scrap which together is called as field coagulum rubber.

- 1) Tree lace: The latex which gets dried up on the tapping panel.
- 2) Shell scrap: The latex which dried up in the collection cups.
- 3) Earth scrap: The latex that is split and/ or overflowed on the ground (earth scrap) which gets dried up. It is also collected once in a month or so.

Marketable forms of natural rubber includes; (Rubber forms processed for marketing)

- ➔ Sheet rubber: Prepared by addition of anticoagulants viz., Ammonia, Sodium Sulphate and Formalin.
- ➔ Crepe rubber : When coagulum is passed through crepeing machine,
- ➔ Latex Concentrates/ Preserved field latex : Obtained by centrifuge machine,
- ➔ Block Rubber/ Crumb rubber:

Anticoagulants: It is a chemical added to latex to prevent pre-coagulation before it is processed.

Eg: Ammonia, Sodium Sulfate, Formalin etc.

Systems of tapping

Rubber attains tapping stage at about 7 years of age during which period, required girth is attained (i.e., 55cm girth at 50 cm height) from ground.

Time of tapping: Early in the morning (Late tapping will reduce latex flow)

Tapping task: Number of trees tapped in a day by one tapper. In India it is 300 trees compared to 400 to 500 trees in other countries.

Sl. No.	System of tapping	Intensity	Remarks
1	$\frac{1}{2} S \frac{1}{2} d$ i.e., s_2d_2 (half spiral cutting and tapping at alternate days for 6 months and rest for 3 months)	100 per cent	Recommended for budded plants
2	$\frac{1}{2} S \frac{1}{3} d$ i.e., s_2d_3 (half spiral cutting and tapping at every 3 days for 6 months and rest for 3 months)	$\frac{1}{3}$ day = 67 % $\frac{1}{2}$ cut	Recommended for clonal seedlings
3	$\frac{1}{2} S d_1$ i.e., s_2d_1 (half spiral cutting and tapping daily for 6 months and rest for 3 months)	$\frac{1}{1}$ day = 200 % $\frac{1}{2}$ cut	Followed by small growers and it results in early deterioration of trees.

Tapping system depends on the

- 1) Intensity of cut and
- 2) Periodicity of tapping.

Slope of tapping panel to horizontal zone in tree:

- a) Budded trees = slope down by 30 °
- b) Seedling = 25°

Slaughter tapping in rubber: The term slaughter tapping is used to indicate all out bleeding of rubber tree to obtain maximum yield without regard to health or longevity of trees. It is done one or two years before replanting or replacing crop.

In old trees tapping is done by giving two or more half spiral cuts simultaneously i.e.,

1. one at the base level and other at
2. at least 120 –180 cm higher level on the opposite side.

Slaughter tapping is sometimes practiced even on branches with the help of ladders. Here length, height and frequency of tapping are all increased.

Chemical methods of yield increase:

Chemical used: Ethrel (2, chloroethyl phosphonic acid) i.e., ethephon.

Ethrel stimulate and increase the yield of rubber latex flow at least by two folds. Ethrel has to be diluted with coconut oil to have 10 per cent active ingredient. Judicious application of dilute (1 to 5 % active ingredient) ethephon on the panel or on the bark at prescribed intervals and seasons enhances the yield.

Method of application: Bark application with a brush below the tapping cut to a width of 5 cm after light scrapping of outer bark.

Schedule of application:

- 1) After drought period, preferably after few premonsoon showers
- 2) Subsequent application during September
- 3) November

Latex can be processed into any of the following forms

1. Preserved field latex and latex concentrate
2. Sheet rubber
3. Block rubber
4. Crepe rubber

Field coagulum can be processed only into crepe rubber or block rubber.

Question Bank

1. What do you mean by tapping in rubber?
2. Mention the systems of rubber tapping
3. What do you mean by slaughter tapping in rubber ?
4. _____ growth regulator is used for the stimulation of rubber latex flow (Ethrel)
5. Tapping stage in rubber is attained in about _____ years of planting (7 years)

LECTURE 27

COFFEE (*Coffea* spp.)

FAMILY: Rubiaceae,

Arabica coffee = *Coffea arabica* = $2n=44$ = a tetraploid and self pollinated- 80 per cent of world coffee

Robusta coffee = *Coffea canephora* = $2n=22$ a diploid – self sterile and cross pollinated. Nearly 20 per cent (Suited for instant coffee and generally utilized for cherry coffee.

Tree coffee = *Coffea liberica*

Coffea bengalensis = Tree coffee Wild in Bengal, Myanmar (Burma) and Sumatra
Occasionally cultivated in India

Origin of coffee

Arabica coffee: Originated from Ethiopia, from a place called Caffa. The word coffee is derived from the place called caffia. Here it occurs naturally in the forest between 1,400 to 1,800 feet elevation.

Robusta coffee = Believed to be originated from Central Africa (Congo and Zaire region)

Introduction of coffee to India

Arabica coffee: It was introduced in 1670 by Muslim pilgrim Baba Budan. He brought seven seeds from Yemen and cultivated in Chikmagalur, Karnataka. The original seeds he brought were probably Mokka seeds.

Robusta coffee: It was introduced from Indochina region at the close of 19th Century for planting in the estates of lower elevations

Distribution of coffee:

Distribution of coffee: Coffee is susceptible to frost and hence, distribution is limited by temperature.

World: It is distributed between 25° N and 25° S

coffee	Area Harvested (ha)	Yield (kg/ha)	Production (tonnes)
Brazil	2001340	12192	2440060
Vietnam	504100	23328	1176000
Colombia	768000	11558	887661
Indonesia	980000	7142	700000
India	343000	8440	289500
Ethiopia	395003	6720	265469
Peru	342600	7443	255016
Mexico	788984	3193	252000
Guatemala	251024	9930	249275
Honduras	230000	8947	205800
	9841317		8342636

- Cultivation is mainly in developing countries but consumption is largely in developed countries: Cultivated in about 80 countries mostly of developing world. Total area under coffee is 11.6 million ha.

Sl.No. /Position	Country	Percent of world area under coffee
1	Brazil	21.2
2	Ivory Coast	12.3
3	Columbia	9.9
4	Indonesia	9.1
5	Mexico	5.2
6	Angola	4.5
7	Uganda	3.5
8	India	2.6
9	Other countries	31.8
	Total	100

Coffee distribution in India:

Area under coffee in India (2.60 per cent of world acreage (8th position in the world) India accounts for 3 per cent of world coffee production.

In India area under arabica coffee is nearly 49 per cent while that of robusta coffee is nearly 51 per cent of total coffee area.

PRODUCTION OF COFFEE IN MAJOR STATES/DISTRICTS OF INDIA

State/District	Post Monsoon Estimation 2010-11			Post Blossom Estimation 2010-11		
	Arabica	Robusta	Total	Arabica	Robusta	Total
Karnataka						
Chikmagalur	37,475	36,000	73,475	39,825	37,000	76,825
Kodagu	20,900	88,600	109,500	22,050	90,750	112,800
Hassan	17,150	11,690	28,840	18,050	11,950	30,000
Sub total	75,525	136,290	211,815	79,925	139,700	219,625
Kerala						
Wayanad	0	54,500	54,500	0	55,475	55,475
Travancore	900	7,200	8,100	900	7,300	8,200
Nelliampathis	700	1,400	2,100	700	1,400	2,100
Sub total	1,600	63,100	64,700	1,600	64,175	65,775
Tamil Nadu						
Pulneys	5,700	225	5,925	5,700	225	5,925
Nilgiris	1,675	3,725	5,400	1,700	3,725	5,425
Shevroys (Salem)	3,600	50	3,650	3,600	50	3,650
Anamalais (Coimbatore)	1,000	500	1,500	1,000	500	1,500
Sub total	11,975	4,500	16,475	12,000	4,500	16,500
Non Traditional Areas						
Andhra Pradesh	5,600	65	5,665	5,615	75	5,690
Orissa	200	0	200	260	0	260
Sub Total	5,800	65	5,865	5,875	75	5,950
North Eastern Region	100	45	145	100	50	150
Grand Total (India)	95,000	204,000	299,000	99,500	208,500	308,000

Size of holdings in India: About 98 per cent of Indian coffee growers are of small holding (i.e., < 10 ha) accounting to 1.48 lakh growers.

2) Production and productivity of coffee in India:

Productivity of Arabica coffee = 815 kg/ha

Productivity of Robusta coffee = 1065 kg/ha

Average productivity = 946 kg/ha

Important differences between arabica and robusta coffee

Important differences between Arabica and robusta coffee

Sl. No.	Characters	Arabica coffee (<i>C. arabica</i>)	Robusta coffee (<i>C. canephora</i>)
1	Ploidy	Tetraploid (2n =44)	Diploid (2n =22)
2	Adoptability	Higher elevations (1000 to 1500m)	Comparatively lower elevations (500 to 1000m)
3	Plant stature	A small tree, shrub or a bush under training.	Bigger tree than Arabica
4	Number of days for blossoming after the receipt of blossom showers	9 to 10 days	7 days
5	Berries per node	10 to 12 per node but bigger	40 to 60 per node but smaller
6	Fruit development period	8 to 9 months	10 to 11 months
7	Root system	Small but deep	Large but shallow
8	Pollination and fertilization	Self fertile and self pollination	Self sterile and cross pollination

Question Bank

- 1) Differentiae between arabica and robusta coffee ?
- 2) Robusta coffee is tetraploid – True or False (False – Arabica is tetraploid)
- 3) Type of pollination in Arabica coffee is _____ (self)
- 4) Botanical name of tree coffee is _____ (*Coffea liberica*)
- 5) Mention major coffee producing countries in the world.
- 6) _____ state produces maximum coffee in India (Karnataka)

LECTURE 28

Soil and climatic requirement

Soil: Coffee is not very specific with respect to its soil requirements. Important features of ideal soil for profitable coffee cultivation are

- 1) **Soil depth :** It should be more than 75 cm
Shallow or compact soil: Poor root development and spread. Roots develop only on upper horizons and it rarely goes deeper than 30 cm
Deep and permeable soil (>75 cm): Well developed tap root system, and rhizosphere occupy considerable soil volume.
- 2) **Soil P^H:** Slightly acidic to neutral pH is preferred (PH of 4.50 to 6.00 and even upto 7.00)

Table: Soil and climatic requirement for coffee

SL. No.	Climatic Factors	Arabica coffee	Robusta coffee
1	Soils	Deep, friable, rich in organic matter, well-drained and slightly acidic P ^H (P ^H of 6 to 6.50)	Same as in arabica
2	Extent of Slope	Gentle to moderate slope is ideal	Gentle slope to fairly level fields to be preferred
3	Aspect	North/East/North-Eastern aspects are ideal	North/East/North-Eastern aspects are ideal
4	Elevation for better growth and yield (m)	1000 to 1500m	500 to 1000m
5	Temperature	15 °C to 25 °C, cool equable	20°C to 30 °C, hot, humid
6	Relative humidity	70 to80 %	80 ot 90 %

7	Annual rainfall	1600 mm to 2500 mm	1000 to 2000 mm
8	Blossom showers (25 to 40 mm)	March – April	February – March
9	Backing showers (50-75 mm)	April – May	March – April
10	Extent of shade	Medium to light shade depending on the elevation and aspects	Uniform thin shade

Climate for coffee

Coffee is more exacting in its climatic requirement than its soil requirements.

Important climatic parameters deciding coffee performance and production

- 1) Rainfall
- 2) Temperature
- 3) Humidity
- 4) Altitude

Table: Climatic factors adversely affecting production of coffee

Sl. No.	Climatic Factors	Arabica coffee	Robusta coffee
1	Absence of blossom showers during	March- April	March
2	Absence of backing showers during	Delayed beyond one month after blossom showers – Poor crop set	Delayed beyond 20 to 25 days after blossom rain - Poor crop set
3	Hail storms	Injures floral and vegetative parts	Same damage as in arabica coffee
4	Rain on the day of blossom	Partial or complete failure of the crop	Partial crop failure
5	Western/Southern Exposure (with poor soil moisture)	Partial or complete failure	Partial crop failure

6	Wind exposure	Sensitive	Sensitive
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Rain fall for Coffee cultivation: Well distributed rainfall is preferred for coffee cultivation with dry months from December to March.

Summer showers === Important for flowering in coffee.

Backing showers === Coffee is shallow rooted crop and can not exploit soil moisture from deeper sub soils. Hence, for good fruit development backing showers is suggested.

Arabica Coffee varieties developed at CCRI Balehonnur

	Variety	Method of crop improvement	Feature
1	Selection-1	S-288	Has high percentage of defective beans due to false poly embryony
2	Selection-2	Pedigree selection	Seed distribution of this selection was withdrawn due to high bean abnormality
3	Selection-3 (S- 795)	Multiple crosses (Released in 1945-46)	S-288 (S31-1) x Kents arabica = Selection –3 (S-795) Has least bean abnormality when compared to S-288 (Selection-1) ✓ Occupied large area under coffee since its release in 1945-46 ✓ High yield = 20 q/ha ✓ Good cup quality ✓ High proportion of A grade beans.
4	Selection-4	Pure line selection	
5	Selection-5	Hybridization	
6	Selection-6	Interspecific hybridization followed by back crossing	S-274 (A robusta type) X Kents (Arabica) = F1 , F1 was back crossed with Kents
7	Selection-7 (San Raman Hybrids)	Multiple crosses (1953)	San Raman is a dwarf mutant from Costa Rica – An arabica type. Introduced int India in 1953. This mutant segregates into 70 per cent Dwarfs and 30 per cent Tall plants.

			Suitable for high density planting.
8	Selection – 8 (Hibrido- De timor)	Pure line selection (1968 –69)	Spontaneous hybrid of robusta and arabica, spotted from Timor island and was given for cultivation from 1968 -69
9	Selection-9	Hybridization	Selection-8 X Tafariquera = Drought hardy and widely adopted plants. Sln.9: Selection 9 is a derivative of a cross between an Ethiopian Arabica collection, ‘Tafarikela’, and ‘Hybrido-de-Timor’. Sln.9 has inherited all the superior cup quality traits of Tafariquera. This variety has won the Fine Cup Award for best Arabica at the ‘Flavour of India - Cupping Competition 2002’ organised by Coffee Board of India.
10	Selection – 10	Double crosses	Caturra crosses other than HDT, Caturra is highly susceptible to rusts
11	Selection – 11	Interspecific hybridization	C. liberica X C. eugenioides obtained through amphiploidy. It resembles arabica and is resistant to leaf rust and moderately tolerant to drought.
12	Selection – 12- (Cauvery/ Catimor)	Exploitation of natural hybrids by involving hybridization	Cross between Caturra X HDT*

Cauvery Coffee (Selection –12)- Features:

Cauvery hybrid is a F₄ Cross between

Caturra (A semi dwarf variety of arabica) X Hybrid de Timor (A semi-dwarf hybrid)

This variety has gained popularity among growers and it is occupying more than 25 thousand ha area.

Features of Cauvery Coffee;

- 1) **Suitable for High Density planting:** Cauvery is a compact bush with vigorous vegetative growth suitable high density planting.
- 2) **Profuse branching:** It is profuse branching, semi erect and droop when bearing.
No. of primaries upto 1 m height (i.e., at first topping height) = 16 to 20
Nodes per primary= 16 to 20 (i.e., very close internodes)
- 3) **Precocious :** Early flowering and = Early bearing
- 4) **Reaction to leaf rust :** At the time of release it showed high resistance to leaf rust.
However, from fast 5 to 7 years the resistance has been broken down due to the appearance of 7 new rust races.
- 5) **Yield :** High yielder = 30 q/ha(Under average management) to 60 q per ha (Under intensive management)
- 6) **Quality :** Medium sized beans with
64 % A grade and
15 % B grade beans.
Beverage quality = Cup rating = FAQ to good = Fair average Quality

Chandragiri coffee:

It is a newly released coffee in 2007-08 by Coffee Board with the original source from Portugal

It was introduced in the year 1975 to CCRI Balehonnur from Portugal. Farm trials and intensive research trials were taken up at CCRI Balehonnur.

Features:

- 1) Bushy growth with slightly bigger leaves than Cauvery coffee
- 2) Bigger sized berries: It produces 25 per cent bigger sized berries compared to other varieties.
- 3) Resistant to leaf rust: Lower (5 to 7 %) leaf rust incidence in this variety is reported compared to other varieties (20 to 40 %).

- 4) Tolerant to drought

Improvement of robusta coffee (*Coffea canephora*)

Robusta selections from CCRI Balehonnur are

- 1) Selection –1 R (S-270 and S-274)
- 2) Selection –2 R (BR series 9,10 and 11)
- 3) Selection – 3 R (C X R coffee)

Unlike arabica coffee robusta coffee has long productive life of 70 to 80 years and hence, farmers' donot replace the old varieties frequently.

1) Selection – 1R (S-270 and S-274)

It is a seeding progenies of two individual mother palm identified in robusta gene pool in India. It has 35 to 50 fruits per cluster.

Yield: 10 q per ha. Under rainfed condition/

S- 274 is preferred to S-270 on account of its bolder beans and wide adoptability. Among the robusta selections S-274 is most popular and is promising well in planters' field of all robusta tracts in India.

2) Selection 2 R (BR series 9,10 and 11)

Based on individual performance of clones BR (Balehonnur Robusta) 9, 10 and 11 raised from S-274 were found to be promising and seed mixture of these clones was issued as Selection – 2 R.

The population resembles S-274 in growth habit, yield potential and bean/cup characteristics.

Note: It is important to note that only seed mixture of these three clones BR –9, BR-10 and BR-11 should be used for planting. Individual clones should not be planted separately which may result in no fruit set due to incompatibility problems.

3) Selection – 3 R, (C X R)

It is a inter specific hybrid between

Coffea congensis X *C. canephora* (Robust coffee i.e., Selelction- 274) = F1 (CXR)

F1 is back crossed with both the parents (Robusta and congensis)

Coffea congensis is a species closely related to both arabica and robusta with compact bush, drooping branches and better bean quality than robusta.

Yield : 12 q/ha

Speciality : 1) Can be planted at a closer spacing of 8 ‘ x 8’ than S-274 (i.e., 10 ‘ x10’)

Question Bank

- 1) Blossom shower requirement in arabica coffee is during _____month
(March- April)
- 2) Mention the features of Cauvery coffee
- 3) Mention released varieties in Arabica coffee
- 4) What are the features of Selection 3 R or C X R coffee ?
- 5) Write a note on Chandragiri Coffee ?

LECTURE 29

Planting and aftercare

Site selection

The selected site should have following provisions;

- 1) Water supply : As perennial source
- 2) Soil rich in organic matter (humus)
- 3) Gentle Slope : Slope towards N or NE or E direction
- 4) Drainage : Provision should be there for adequate drainage
- 5) Altitude: Minimum of 500 m asl (Arabica 1000 m to 1500m while robusta 500 m to 1000m asl)
- 6) Wind break: Eastern wind during December- February causes injury to plants (cold injury). Hence, wind belts of silver oak or orange or tree coffee should be raised
- 7) Partial shade: Clear natural vegetation for providing required partial shade to coffee growth. It can be done by selective felling /retention of desired species of wild shade trees in the natural forest vegetation.

Spacing and planting:

Spacing

Sl. No	Type of Coffee (species)	Variety	Spacing
1	Arabica	Talls	6' x 6' or 7' x 6' or 7' x 7'
2	Arabica	Dwarfs (Cauvery / Sanramon)	5' x 5'
3	Robusta	Talls (S-274 and old robustas) S-1 R and S-2 R	10' x10' or 12' x 12'
4	Robusta	C x R (S-3R)	8' x 8'
		Other robustas viz., Old robusta and S-274	10' x10' or 12' x 12'

- Plane land = square system of planting
- sloppy lands =Contour planting
- Steep slopes = Terrace planting

Opening up of pits

Time: March-April (Immediately after the first few summer showers to give scope for weathering for about a month (at least 15 to 20 days))

Size of pit: Depending on soil depth /type

45 cm x 45 cm x 45 cm (LBD) - Always leave 15 –20 days for weathering.

Planting material selection for planting:

- A) Seed propagation and
- B) Vegetative propagation

A) Seed propagation in coffee

Preparation of seeds

1. Selection of berries: Only ripe berries are marked from marked coffee trees for seed collection and remove pulp and get beans.
2. Discard floats and defective beans
3. Seed treatment: Treat seeds with fungicide and dry seeds under shade.

B) Vegetative propagation:

- 1) Cuttings and
- 2) Grafting

Propagation by cuttings:

1. **Selection of shoots:** Select orthotropic (vertical shoots) suckers from elite trees.
2. Age of shoot: Semihard wood and of about six months old. (3 to 6 months old shoots are better)

Shade management

Beneficial effects of shade in coffee

- 1) **Quality improvement:** Shade trees form natural canopy and it improves aromatic properties.
- 2) **Improved foliar health:** Shade helps in getting glassy elegant leaves and controls premature yellowing of leaves, defoliation and dieback.
- 3) **Mulching effect:** Leaves shed from the shade trees acts as soil mulch which in turn held in conserving the soil moisture and prevents soil erosion and improves soil organic matter status.

- 4) **Temperature regulation:** Insulation effect leading to buffering effect in soil temperature.
 Winter season = temperature will be warm enough and
 Summer temperature under shade trees: cool
- 5) **Improved organic matter status of soil :** Decomposed leafy materials improves organic matter content of soil. There will be minimum loss of humus under shade thereby improving soil physical conditions.
- 6) **Disease incidence :** some of the diseases viz., *Cercospora* leaf spot and *Colletotrichum* etc are minimized under shaded situations
- 7) **Yield regulations:** Shaded situations prevents over bearing in any of the particular year and results in less variations / fluctuations in annual yields.
- 8) **Wind breaks:** Shade trees serve as wind belts and protects from hailstone damage and damage due to cold wave.

Types of shade trees

Coffee requires filtered sunlight. It can be provided by providing lower canopy (Temporary) or upper canopy (Permanent shade trees).

I) Temporary shade trees / Lower canopy shade trees:

Spacing of temporary shade trees: 6 to 8 m (One shade for every two coffee plants)

Temporary shade trees are lopped periodically to maintain required light.

Examples of temporary shade trees:

- 1) *Erythrina lithosperma* : Dadap or halwana
- 2) *Grevillea robusta* : Silver oak

Tree spices:

Nut meg, clove and cinnamon: Spaced at 5 m apart.

Permanent shade trees / Upper canopy shade trees:

Spacing: 12 – 14 m

Ideal shade trees for coffee - Features

Aim: To get filtered light

Features of ideal shade trees

- 1) Nature of tree: Evergreen: Tree should be evergreen. However, deciduous trees which shed leaves during monsoon can also be used. Eg. *Cidrella toona* (gandhagarige/ Red cedar)
- 2) Flushing interval: Interval between shedding of leaves and emergence of new flush / leaves must be short.
- 3) Feathery leaves: Selected trees preferably should have feathery leaves as to allow filtered light. Avoid dense foliage and broad leaved trees.
Eg : *Albizzia lebbeck*
A. Stipulata
- 4) Clean trunk / Single stem: Trees should produce a clear trunk upto 30-35 feet to avoid damage caused by dripping of rain water.
- 5) Spreading habit: Trees with wider canopy is preferred as to get maximum canopy from minimum number of trees.
- 6) Withstand wind damage : Trees should not be brittle
- 7) Legume: Selected trees should be a legume.
- 8) Economically important: Tree should serve either as a timber (Eg. *Dalbergia latifolia* is a good timber) yielding tree.or fruit plant (Eg. Jack tree) or standard for trailing black pepper (Eg. Silver oak is a very good standard for black pepper and wood is also of good quality)
- 9) Withstand Lopping/ pruning/ trimming.

Shade trees absorb effective rays so that, light quality decreases. In open we get better growth than in shade because of good quality light.

Shade regulation wrt permanent shade trees : Shade regulation is necessary in coffee and it has to be done every year i.e., just before the commencement of monsoon.

Season :May – June – July (Monsoon) by cutting/lopping of branches. It is because during this period coffee receives less sunlight.

Training and Pruning in coffee.

Training in coffee:

Purpose of training:

- 1) **Height restriction:** Main purpose of training in coffee is to restrict the plant growth at desirable height for better management (spraying, harvesting etc)
- 2) **Frame work:** To attain proper shape, strong framework in coffee
- 3) **Bearing wood:** To promote the production of bearing wood.

Types of training

- 1) **Single stem training:** Suitable under India conditions.
- 2) **Multiple stem:** Practiced in American and Latin American countries.

1) Single stem system:

Practiced in India

Topping of growing main-stem

Purpose of topping/capping:

- 1) To restrict vertical growth and facilitating lateral branching giving increased fruiting area.
- 2) Thickening of main stem: It also helps in diversion of food material to thicken the main stem and primary branches.

As soon as the plant reaches a desirable height (first topping height) the growth of bush is restricted by topping/capping.

Table: First topping height in coffee

Sl. No.	Variety	Topping height I - Tire (cm)	Remarks	II Tier height
1	Arabica Tall	60 to 75 (2.5 feet)	In about 9-12 months stage after planting	4.50 to 5 ft
2	Arabica Dwarfs	90 to 135 (3 to 4.5 ft.)		
3	Robusta	105 to 120 cm (3.50 to 4 ft)	In about 18-24 months stage	4.50 to 5.00 ft

Raising of second tier:

Depending on the fertility of the soil and spreading of the plant when plants attain about 4.50 to 5 ft height (135 to 150 cm) the second tier is raised.

2) Multiple stem system (Agobiada system)

Countries: Practiced in African and Latin American countries. Here multiple stems are encouraged by bending the main stem (i.e., Agobiada system

In India multiple stem training system is practiced under certain circumstances *viz.*,

- 1) **Replanted fields:** When old blocks are to be replanted with a new material, the old plants are stumped and converted into multiple stem to yield crops until the new plants come to bearing.
- 2) **High density planting:** Here coffee is planted very closely in the initial years and later thinned out to normal spacing.

Here the plants which are to be thinned out (removed or going plants) are raised on multiple stems for enabling the main plants to spread out their laterals.

PRUNING IN COFFEE

Coffee bean crop on second year wood and hence, require regular pruning.

Purpose/Principles of pruning in coffee

- 1) **To encourage new growth :** In coffee by pruning old unproductive wood is removed there by encouraging the growth of new branches. These new branches/growth would become next year cropping wood.

Benefits of pruning in coffee:

- 1) Yield regulation : Pruning reduces the risk of overbearing in any of the particular year.
- 2) Pest and disease incidence : By pruning there will be better entry of sunlight and air in to the bushes there by minimizing the incidence of pests and diseases.

- 3) Manageable shape : By proper pruning the tree is maintained in a manageable shape thereby improving the efficiency of field operations viz., spraying, swabbing, harvesting etc

Methods of pruning

Light pruning:

- 1) Medium to severe pruning

1) Light pruning:

In coffee trained on single stem regular light pruning is desirable.

Time of pruning: Starts after the harvest of coffee (December to February) and continues till the onset of monsoon. However, it is better to prune after few summer showers.

NOTE: Bushes suffering from exhaustion /die back are to be pruned only when there is sufficient soil moisture.

It also includes periodical handling i.e., periodical removal of suckers. However, it is better to prune after few summer showers.

Parts pruned during light pruning in coffee:

- 1) Old branches
- 2) Unproductive branches
- 3) Criss-cross branches
- 4) Lean and lanky growth
- 5) Whippy wood
- 6) Dead and broken/damaged branches
- 7) Disease and pest affected parts
- 8) Suckers
- 9) Branches touching ground

II) Medium to severe pruning:

Periodicity of medium to severe pruning: It is done once in four years usually to replace the laterals.

Rejuvenation of coffee bushes:

Stumping / Collar pruning: To rejuvenate badly damaged bushes during shade regulation or due to irregular pruning.

Height of stumping: 30 cm from ground level.

Angle of cut slope: Cut has to be made at 45 degree sloping angle facing towards East or North- Eastern direction.

Season of stumping: After the receipt of summer showers i.e., April- May

A vigorous growing sucker from 1 “ below the cut surface is trained on single stem.

Note: Cut surface is pasted with Bordeaux mixture paste to (10 %) prevents rotting and drying of cut surface.

Manuring in coffee

Nutrition Management

- Maintaining optimum pH by liming is essential requirement for nutrition management in coffee. If proper pH is not maintained, the applied fertilizers will not be utilised by the plants effectively.
- Soil testing at least once in 2-3 years should be mandatory for lime and fertilizer applications.
- Use agricultural lime analysing 80% calcium carbonate. November is the best period for lime application. Application of dolomite lime once in a while in rotation is beneficial.
- Application of bulky organic manures like FYM or compost @ 5 tonnes/ha once in two years would improve the soil condition and better utilization of applied fertilizers.
- The recommended dose of fertilizers should be applied in three splits (post-blossom, pre-monsoon, post-monsoon) by adopting drip circle method. In slopy areas, the fertilizers should be applied in the upper half of the drip circle.

Fertilizer recommendation in coffee

Age of plant	(Dose per plant in grams)								
	Pre blossom (March)			Post blossom (May)			Post Monsoon (October)		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
I Year	8	5	8	8	5	8	8	5	8
II & III Year	10	8	10	10	8	10	10	8	10
IV Year	13	10	13	13	10	13	13	10	13
V Year & Onwards	24	15	24	24	15	24	24	15	24

Question Bank

- 1) Write about the spacing in arabica and robusta coffee
- 2) Write about the beneficial effects of shade trees in coffee plantation ?
- 3) What do you mean by temporary shade trees in coffee ?
- 4) Mention the features of ideal shade trees for coffee cultivation ?
- 5) Narrate about single stem system of training in coffee ?

6) Write a short note on a) pruning and b) fertilizer application in coffee ?

LECTURE 30

PLANT PROTECTION IN COFFEE

Diseases:

In India bacterial and viral diseases have not been recorded on coffee (both arabica and robusta). However, both arabica and robusta are susceptible to fungal diseases.

Diseases in coffee : Leaf rust, 2) Black rot, 3) Pink disease, 4) Anthracnose
5) Root diseases etc

Non parasitic disorder

- 1) Kondli (*Copper toxicity*)
- 2) Bean disorder in coffee

1) Leaf rust in coffee and its management

It is an oriental leaf disease. It is considered as one of the seven classic diseases of the world since,

- 1) It ruined the economy of Sri Lanka rendering it bankrupt and
- 2) It changed the social habit of people from coffee drinking to tea drinking.

Cause: *Hemelea vastatrix*

There are 39 physiological races of *Hemelea vastatrix arer* reported of which 23 occur in India.

1868: Leaf rust disease first time observed in Sri Lanka

1869: Observed in India.

Arabica coffee is more susceptible than robusta and excelsa.

Season of occurrence : Throughout the year.

Peak period : August to November

Symptoms of coffee leaf rust disease

Defoliation: Initially small pale yellow spots appear on the lower leaf surface ---- turn ---- orange yellow (Due to powdery mass consisting of uredospores) on the entire surface of leaves due to coalescence of spots -- finally necrotic spots and defoliation.

Barren & dead twig: During favourable year for disease spread the damage is so devastating that, only barren and dead twigs could be seen devoid of cropping branches for the succeeding year.

Crop loss: Crop loss due to this disease may go up as high as 70 per cent.

Management or control measures for leaf rust:

- 1) Replacement with resistant material/tolerant material: Replace the susceptible material in the plantation.
- 2) Chemical control: Bordeaux mixture @ 0.50 per cent concentration.
Alternative fungicides: Systemic, curative and eradicant fungicides can also be used
Viz.,
 - a) Plantvax (Oxycarboxin) 20 EC @0.03 per cent a.i (1.50 ml per litre of water)
 - b) Bayleton 25 WP @0.02 % a.i (0.80 g per liter of water)

Spray schedule

- i) Pre blossom – February – March
- ii) Pre monsoon – May – June
- iii) Post monsoon – September – October

PESTS in coffee

Major insect pests of coffee are as under

Sl. No	Pest
1	White stem borer
2	Coffee berry borer
3	Shot hole borer
4	Mealy bugs
5	Green scales
6	Brown scale
7	White grub / cockchafers
8	Hairy caterpillars
9	Root lesion nematode
10	Coffee bean beetle
11	Snail
12	Red borer
13	Thrips
14	Termites

(1) White stem borer (*Xylosandrus quadripes*/*Xylotrechus quadripes*)

Most serious pest of arabica coffee in India

Robusta coffee is free from this pest

Method of damage: Grubs feed on the corky portion under the bark for about two months.

Symptoms of attack: Spitting of bark == Tunnelling even hard wood in all the directions
 == Externally visible ridges are seen around the stem == Yellowing and wilting of leaves
 == Less productivity with more of float beans (floats)

Management of white grub in coffee:

- 1) Shade management: Maintenance of optimum shade
- 2) Removal of affected parts /trees prior to flight period: Prior to flight period (i.e., the period of emergence of adult beetles and in flight period beetles will escape by flying) Once in April – May and other in October – December.
- 3) Minimising the scope for egg laying i.e. , **Scrubbling** : Eggs are laid on the loose scaly bark of the main stem and thick primaries. Hence, removing loose scaly bark of main stem and primaries using coconut husk is suggested. Scrubbling (rubbing) during flight period not only prevents egg laying but also kills eggs and grubs.
- 4) **Swabbing** /Spraying: During April – May, and October – November

Insecticide recommended: Lindane 20 EC @ 6.50 ml per litre of water. (i.e., 1300 ml per 200 litres barrel)

Spraying of main stem and thick primaries with neem kernel extract may be effective. However, as the persistence of neem derivatives is only for a short period, repeated applications may become necessary.

Harvesting and yield

Hastening fruit ripening in coffee:

Purpose: Speedy and uniform ripening will give scope for quick and early harvest = reduced cost of harvesting in coffee.

Harvesting the berries:

In India there is only one cropping season. Arabica coffee harvested from November to January and Robusta coffee from December to February. The crop will be ready for the first harvest in about 3 - 4 years but economic yields are obtained from 5 - 12 years onwards upto 50 years. The berries are harvested when they turn red to deep crimson colour. Season of harvest is from October to February. Harvesting is done in stages as follows;

Fly picking: Small scale picking of ripe berries from October - November to February.

Main picking: Well formed ripe berries are harvested in December.

Stripping: All left over berries irrespective of ripening are harvested after main picking.

Gleanings: Collection of fruits that have dropped down during harvesting.

Processing in coffee for parchment and cherry coffee preparation

Coffee is processed by two methods viz.,

- 1) **Wet method** – to prepare plantation or parchment coffee.
- 2) **Dry method** – to obtain cherry coffee.

Wet Processing in coffee: It is for the preparation of plantation or parchment coffee which is preferred in the market. **Wet processing involves the following steps;**

1) Collection of ripe berries : For both types of processing picking of fruits at correct stage of ripening (just ripe berries – on gentle squeezing the fruit, beans inside pop up easily and the colour of berries changes to red or crimson) is essential. Just ripe berries are ideal for pulping, to prepare parchment coffee.

Over ripe or under ripe berries results in poor cup quality on processing. If harvesting could not be done in time the over ripe, under ripe and green coffee should be sorted separately and processed for cherry coffee.

2) Pulping: Removal of outer skin of ripe berries by soaking in water. Pulp the ripe berries on the same day to avoid fermentation before pulping.

3) Demucillaging and washing : Demucillaging can be done by

a) Natural fermentation : Arabica = 24 to 36 hours

Robust = > 72 hours because of thicker mucilage

Overfermentation = Leads to foxy beans

Under fermentation = Sticky mucilage is left out = Leads to absorption of moisture by beans = Mistiness.

Proper fermentation = Mucilage come out easily beans when squeezed by hand.

b) Enzymatic fermentation = Pectinolytic enzymes can be used.

c) Chemical demucillaging : Treatment with Alkali. Here 10 % solution of Caustic Soda (Sodium Hydroxide) is used.

d) Removal of mucilage by friction:

4) Washing: Washing in clean water after soaking for 24 hours (overnight) = Improves quality and appearance.

5) Drying: Seeds spread on the mats in the open for drying.

6) Hulling: Removal of outer coat like epicotyl and parchment along with testa. The brittle, dry husklike parchment (endocarp) is removed by machines and the silver skin is removed by polishing.

7) Polishing: Removal of adhering testa

7) Sorting:

8) Bagging: Coffee beans readily absorb foreign taints (Blemish) and odours and hence, suitable care should be taken.

2) Dry method – to obtain cherry coffee.

- 1) Harvesting of ripe berries
- 2) **Drying:** Drying of ripe berries for 12 to 15 days in bright sun until rattling sound is heard when shaken. Drying usually takes 12 to 15 days with intermittent stirring (Hourly in the beginning)
- 3) **Bagging:** The greenish grey seeds are graded and are then usually packed for export purposes.

Roasting: The coffee beans are roasted at 500 ° F or 270 ° C for 5 minutes. The roasted coffee beans have 0.5 to 1.50 per cent caffeine.

Grinding:

Grinding of roasted beans is the last step in the preparation of coffee powder.

Question Bank

- 1) Mention the major pests and diseases of coffee ?
- 2) How do you manage leaf rust disease in coffee ?
- 3) Write about the symptoms of white stem borer damage in coffee.
- 4) _____ coffee is free from white stem borer incidence (Robusta coffee)
- 5) Write about the stage of harvesting and two methods of processing in coffee ?

COCOA (*Theobroma cacao* L.)

Introduction

Family : Sterculiaceae,

Cocoa is a popular beverage crop after tea and coffee

Theobroma : Name given by Linnaeus meaning “ Food of the Gods

Greek name Theos = Gods and Bromo = Food

Cocoa consumption is mainly in temperate countries.

Europe : 50 percent of consumption of cocoa produced in the world

America : 40 percent of consumption of cocoa produced in the world

Cocoa is relatively a new crop in India,

Cocoa (***Theobroma cacao* L.**) is a native of Amazon region of South America. The bulk of it is produced in the tropical areas of the African continent. There are over 20 species in the genus but the cocoa tree *Theobroma cacao* is the only one cultivated widely.

Cocoa being a tropical crop, India offers considerable scope for the development. Cocoa is mainly grown in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu.

Importance:

Though cocoa has been known as the beverage crop even before tea or coffee, it is relatively a new crop in India. Cocoa being primarily an item of confectionery industries is the produce of Cacao plant mostly grown as a companion crop interspersed within the irrigated Coconut and /or Arecanut gardens. Even though Cocoa comes under the definition of plantation crops pure plantation of cocoa as such is absent in India. The commercial cultivation of cocoa however commenced from 1960's only. Various Cocoa products are confectionery in nature and consumable with palatable ness. Internationally it is an item largely consumed in developed countries. India has gained a foreign exchange of nearly Rs. 9.00 crores in 1995-96 and Rs. 6.00 crores in 1996-97 by way of export of cocoa beans and its products from India. At present the global production and consumption of cocoa is around 27.00 lakh MT, compared to this, India's production is meager i.e. 10,000 MT.

Early sixties : Introduced to India for commercial cultivation

> 1965 : Commercial cultivation of cocoa

1970's : Large scale cultivation of cocoa

Origin and distribution,

Origin : Cocoa is native of Amazon region of South America.

- ❖ Under storey crop of rain forest in its natural habitat. Since 2000 years: Cocoa was under cultivation in Central America. Central American cocoa is Criollo cocoa.

Distribution :

World : About 35 countries in the world are producing and exporting cocoa

Ghana, : African country : 30 per cent of world production.

Nigeria, : African country.

Ivory Coast, : (In Western Africa by the western side of Ghana) Leads in the world with 40 per cent of world production followed by Ghana (30 %)

Brazil : 20 per cent of world production

Cameroon and Malaysia.

Asia : Only 2 % of world cocoa production Central American cocoa : Criollo

Are and production of cocoa in the world

	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
Côte d'Ivoire	2000000	6108	1221600
Indonesia	1000000	8000	800000
Ghana	1656000	4000	662400
Nigeria	1370000	2700	370000
Cameroon	600000	3766	226000
Brazil	635975	3435	218487
Ecuador	398104	3028	120582
Togo	138160	7599	105000
Papua New Guinea	128000	3984	51000
Dominican Republic	173000	2901	50200
Colombia	127988	3855	49348
Peru	68860	5246	36124

Mexico	61317	3695	22661
Venezuela (Bolivarian Republic of)	50000	4000	20000
Malaysia	20561	8828	18152
Uganda	43000	3488	15000
India	34049	3471	11820
Total	873309 3	24977 2	4082270

Earlier cocoa was grown mainly in South America (Brazil, Ecuador and neighboring countries). Now two thirds of the world production is from Africa (Ghana and Nigeria)

India:

Early 1970's : Commercial cultivation in India started.

80 % of cocoa plantations : As intercrop/mixed crop with arecanut and coconut plantation

20 % of cocoa plantations: Under crop of partially cleared forest.

Area : 11,000 ha

Production : 7,000 tonnes

Productivity : 605 kg per ha

Marketing of cocoa in India is controlled by few companies like Cadbury's, Sathe etc and they import cocoa at lower rates. Now cocoa crop is included under CAMPCO (Central Arecanut and Cocoa Marketing and Processing Co- Operated Limited)

State wise Area, Production & Productivity of Cocoa

A - Area in Ha.

PDN - Production in MT.

PDY - Productivity in Kg./Ha.

STATE	2008-09			2009-10		
	A	PDN	PDY	A	PDN	PDY
Kerala	10708	6100	685	11044	6344	592
Tamil Nadu	8500	230	350	9347	900	443
Karnataka	7250	2890	600	8958	7250	3006

A.Pradesh	14061	2600	565	16969	2704	192
TOTAL	40519	11820	550	46318	12954	380

<http://dccd.gov.in/stat2.htm#State>

Sl No.	State	Area (% of total area)	Production (% of total production)
1	Kerala	79	71
2	Karnataka	18	25
3	Other states viz., AP, TN. Etc		

There is scope for expanding area in TN, Goa, Maharastra and North Eastern region, Andaman and Nicobar islands

Climate and soil

Climate and Microclimatic requirement: Cocoa is a tropical crop. In its natural habitat cocoa is a small tree in the lower storey\ under storey of the evergreen tropical forest of South America. The tree can not withstand high winds drought and sudden fall in temperature. The microclimatic environment around the cocoa plants consists of a high humidity at all times. It prefers high temperature under partially shaded situation.

Latitude : 20° N and 20 ° S but maximum concentration is between 10° N and 10 ° S

Temperature: Temperature range of 15 to 39° C with a an optimum temperature of 25 ° is considered ideal. Temperature below 10 ° C and annuall average temperature is less than 21 °C. Cocoa responds well to high temperature (30 °C to 32 °C) than lower temperature.

Rainfall : In the absence of irrigation facilities minimum requirement of rainfall is about 150-200 cm per year. Ideally cocoa requires a minimum of 90-100mm rainfall per month with an annual precipitation of 150 -200 cm. Rainfall can be supplemented with irrigation during dry periods.

Altitude : Preferably below 300 M asl. However, it can be grown up to 900m.

Relative Humidity : It prefers hot and humid atmosphere (> 80 % through out the year) is essential for optimum development of cocoa trees. Humidity has to be maintained near saturation

Microclimatic requirement :

Cocoa needs sunlight to be screened to a certain extent particularly during dry weather period. Cocoa is a under storey crop of Amaon fores of S.America.

It can be profitably cultivated where 50 % of light is available. In India, coconut and arecanut plantations are best suited for cocoa cultivation.

Under arecanut 30-50 percent of sunlight penetrates through the canopy, which can be intercepted by cocoa.

Shade can not limit cocoa production when all other environment factors are favorable viz.,

- Optimum temperature : 30-32 ° C
- Excellent average RH :
- Optimum rainfall
- Humus rich soil enriched with fertilizer etc.

Soil : Deeper and richer soils are favorable. The best soils are forest soils rich in humus. A minimum of 3.5 per cent Organic matter in top 15 cm soil is expected for ideal growth.

Deep : (i.e., > 1.5 m)

Well drained :

p^H: 6.5 to 7.0 is ideal. However, it thrives on wide range of soil types with PH ranging from 4.5 to 8.0

Note: At lower pH (<5.0) : Less availability of P and toxic quantity of Fe, Mn, Cu and Zn. And at higher (> 7.0 P^H) Deficiency of trace elements particularly Zn.

Varieties : Varieties / cultivars

There are three main types of cocoa viz.,

1) Criollo group : Here pods are red before ripening, varying in shape and turn yellow on ripening. Its fruits have furrows on fruit surface and have rough warty fruit surface.. It is generally poor yielder with slow growing habit and small leaves. It is susceptible to various diseases.

Criollo types have very weaker chocolate flavour but may have other flavours and is highly priced by some buyers.

2) Forastero group : It is the commercially cultivated type of cocoa in major cocoa growing countries. Here pods are green before ripening and turn yellow on ripening. Pods are of smooth surface and have shallow furrows on it. Seeds have dark purple cotyledons and seeds are more or less flat.

When compared to Criollo it is more vigorous and high yielder. It has good plain chocolate flavour and good for milk chocolates

3) Trinitarios Group of cocoa : It is originally selected from Trinidad. It is heterogenous type probably resulting from Foretero and Criollo cross. It has botanical features of intermediate nature between Criollo and Forestero types. The product of this group is also of intermediate in quality.

The cocoa cultivars in different countries vary with the region from which they were introduced and the amount of hybridization. Commercial cocoa has two major varieties, Criollo and Forestero which differ in many aspects as follows.;

Sl. No	Features	Criollo	Forestero
1.	Cotyledons	Plumpy & white when fresh & on fermentation attains cinnamon colour.	Flat and purple when beans are fresh and turn dark chocolate brown on fermentation. turn dark chocolate brown on fermentation
2	Plant vigour	Less	More vigourous than Criollo
3	Colour of the pod	Dark red	Green when immature and turn yellow on ripening. and turn yellow on ripening.
4	Other pod characters	Rough surface, ridges prominent, pronounced point and thin walled.	Smooth, inconspicuous ridges, thick walled, melon shaped with rounded end
5	Beans per pod	20-30	> 30
5	Flavour and aroma and quality	Mild flavour and pleasant aroma with superior quality and are priced more than that of Forestero types.	Harsh flavour with bitter taste
6	Duration of fermentation	3 days	6 days

7	Adoptability in India and yield level	Poor adoptability and low yield and hence discouraged for commercial cultivation	Adoptable with higher yield level and hence recommended for commercial cultivation not only in India but also in the entire world.
8	Disease reaction	More susceptible for disease particularly that are caused by <i>Phytophthora palmivora</i>	Less susceptible

Other types of cocoa includes

- 1) Trinitario: A hybrid between Criollo and Forastero from Trinidad.
- 2) Amelonado: A Forastero type bean with a melon shaped pod cultivated in west Africa.
- 3 Amazon: Vigourous growing and high yielding type collected from Amazon forests.

The accession numbers of I-21, II-11, II-18, II-67, III-5, III-101 from Malaysian collection were having desirable characters like high yield, bean weight of more than one gram and are recommended for cultivation in South India.

Propagation in cocoa :

Cocoa can be planted either as

- 1) Seedling or through
- 2) Vegetative propagated material

Seed propagation: At present, commercial propagation of cocoa is through seedlings.

Use ripe pods and seeds will lose viability soon after they are taken out of pods. Hence, fresh beans are used for sowing. Seed viability can however be enhanced for several weeks when kept mixed with charcoal. Pods as such stored in polythene bags and dry charcoal powder retained viability upto a period of 30 days.

Vegetative Propagation

Cocoa being a cross pollinated plant seedlings show considerable variability. Vegetative propagation is through

- 1)cuttings,

2) budding : i.e., Forket method of budding or 3) soft wood grafting.

3) Grafting (Soft wood grafting) :The soft wood grafting technique was first standardized at Vittal Station of CPCRI using four months old seedlings as root stock. Scion collected from high yielding plants with other desired characters, were grafted on the seedlings which gave 60-80% success

Soft wood grafting in cocoa : Vegetative propagation is important since true to type trees are produced. Soft wood grafting is a more preferred vegetative method for production of planting material. The material consists of cleft grafting of scions to 2-3 month old seedlings root stocks.

<http://dccd.gov.in/ctech.htm#about>

Age of root stock : 2- 3 months old

Length of scion stick : 12-14 cm

The scion sticks should be 12-14 cm long and secured to root stock cleft by 1.5 cm wide polythene tape. Graft union takes place within one month . The grafts will be ready after 3 months for planting.

Planting cocoa as mixed crop with arecanut/Coconut plantation.

Pit size : 50 cm x 50cm x 50 cm

Fill pits with top soil and 25 kg FYM and plant seedlings of 6 months old

A) Under Forest areas (As pure crop) : Forest trees are thinned to the desirable shade levels if natural partial shade is available. Other wise plants of silver oak or glycidia may have to be raised 2-3 years before planting of cocoa.

Spacing : 2.5 m x 2.5 m to 3.0 m x 3.0 m

Cocoa can be successfully cultivated as a mixed crop with both arecanut and coconut. In India cocoa cultivation is under coconut and arecanut gardens.

B) Cocoa as a mixed crop with arecanut :

Both arecanut and cocoa needs shade during the first two hot weather seasons after planting. Banana can be grown as a shade crop. During subsequent years shade cast by areca palms will provide the required shade for cocoa.

Spacing and alignment

Spacing for arecanut (Main crop) : 2.7 m x 2.7 m
 Spacing for cocoa : 2.7 m x 5.4 m * (* = one row of cocoa for every two rows of areca)
 Plant population of cocoa per ha : 686 plants per ha.
 Drainage channels : There will a drainage channel for every two rows of arecanut (i.e., at 5.4 m apart)

If arecanut is planted in quincunx method at 4m x 4m spacing : Cocoa occupies the centre of the square

Spacing in arecanut plantation as a crop	Population per ha
2.7 m x 5.4 m	686

C) Cocoa as a mixed crop with Coconut:

Single hedge system :cocoa at 2.7 m apart between cocoa plants in between two rows of coconut.

Double hedge system (Paired row system) : cocoa at 2.5 m apart in double rows in between two row of coconut.

A row of cocoa is planted, between 2 rows of coconut when a spacing of 7.5 m x 7.5 m is provided for cocoa. Here cocoa is planted at a spacing of 3 m with in row (i.e., 3 m x 7.5 m) accommodating a population of 444 plants per ha. One more cocoa plant each can logically come between columns of coconut leading the population to 614 per ha (444 + 170 = 614).

If the spacing is more, it may be possible to accommodate even 3 rows of cocoa between coconut rows.

Spacing in coconut plantation as a crop	Population per ha
2.7 m x 2.7 m (single hedge)	1370
2.5 m x 2.5 m (double hedge)	1600

Manuring and irrigation,

Manuring :

FYM per tree : 25 kg at the time of planting and annually there after

Annual dose for trees of 4 years and above : :100 g N : 40 g P₂O₅: 14 g K₂O per tree per year

Dosage of fertilizer application.

Critical stages for fertilizer application in cocoa :

1. Before the main flush
2. Before flowering
3. About 2 months before the main harvest when developing crop has greater demand for nutrient.

In four equal splits during April-May, Sept-October, November-December and February-March.

(Per plant per year)

Age	-----			
	FYM (Kg)	N (g)	P ₂ O ₅ (g)	K ₂ O (g)
i Before planting	25	--	--	--
ii After first year	25	25	10	35
iii After second year	25	50	20	70

iv	After third year	25	75	30	105
v	After fourth year & onwards	25	100	40	140

Apply Farm Yard Manure before the onset of monsoon. Fertilizers may be applied in four equal doses during April-May, Sept-October, November-December and February-March.

Method of fertilizer application : Ring method

Fertilizers may be applied uniformly around the base of the tree upto a radius of 75cm leaving 0.50 m at the base of the tree and forked and incorporated into the soil, to a depth of about 15cm (6").

The bands are to be widened with age. However, in mature cocoa (When canopy is properly closed) fertilizer should be broadcast on the soil surface through out the field.

Irrigation in cocoa

Cocoa plants are sensitive to drought. Young trees requires more frequent irrigation.

Summer irrigation : Cocoa requires continuous supply of moisture for optimum growth and yield. If adequate water supply is not ensured during summer yields will be reduced drastically.

Interval of irrigation in South India during summer : Weekly intervals

When as a mixed crop with arecanut : Irrigate with 175 liters of water as per the schedule given hereunder;

November – December :Once in a week

January – March : once in 6 days

April – May : Once in 4- 5 days

Drip Irrigation : Cocoa responds well to drip irrigation. @ 20 litres per tree per day

Training and pruning of cocoa

Cocoa shows dimorphic branching (i.e., Branching in morphologically distinct forms) .

Jorquette: It is the point where in chupon (i.e., vertical/orthotropic growth of seedlings) terminates to produce fan branches.

Chupon : It is the main stem coming from the seedlings i.e., vertical / orthotropic shoots. It is determinate in growth. A chupon or vertical growth of plant terminates at the jorquette where 4-5 fan branches develop. Further chupon develops just below the jorquette and continues vertical growth till another jorquette is formed.

Fan branches : It refers to the side branches which are plagiotropic in growth and are almost horizontal, produced at the point of jorquette.

Pruning in Cocoa: Cocoa grows in a series of storeyes. The chupon or vertical growth of the seedlings terminate at the jorquette, where 4-5 fan branches develop. Further, chupon develops just below the jorquette and continues its vertical growth till another jorquette forms and so on.

When first jorquette develops at a height of about 1.50m (5ft) the canopy will form at a convenient height for harvesting and other operations. It is desirable to limit the height of the plant at 1.50m (I-jorquette) only by periodical removal of chupon growth. A second jorquette may be allowed to develop if the first one formed is very close to ground. Normally 3-5 fan branches are developed at each jorquette and if fan branches exceeds 5 number remove the weak fan branches.

Pruning of cocoa:

An un pruned trees produces four or more tiers attaining a height of about 15 m or more. Development of branches of the new storey usually leads to degeneration of the lower storey,

Aim of pruning : To get maximum leaf area to avoid self – shading of leaves. Only the branches on the outside part of the canopy (exposed to sun light) of the tree will produce photosynthates and thus make a real contribution to the carbohydrate reserve of the tree. In a cocoa planted at 2.7 m x 5.4 m and a canopy area of 15 -20 m² (is optimum) is found to give higher bean yield.

Cocoa grows in a series of stories or tiers. Seedlings normally grow unbranched to a height of 1 to 2 m. The terminal bud then ceases growth and 3 to 5 lateral branches (fan branches) develop at that point of jorquette. Further increase in height is due to the development of chupon/sucker (Vertical growth) just below the jorquette.

First storey : When first jorquette develops at about 1.5 m height, the canopy will be at a convenient height for harvesting and other operations. Three to five fan branches are encouraged at each jorquette.

Plant protection in cocoa

Disease: Symptoms of attack and control measures of

i) Black pod disease ii) Charcoal rot diseases.

Diseases

(1) Black pod disease (*Phytophthora palmivora*). It also causes seedling die back in the nursery and also canker in the advance age/ stage.

Symptoms: Affected pods turn chocolate brown to black and beans become discolored.

Congenial conditions :

- ♣ Temperature below 21 °C
- ♣ High RH
- ♣ Rainy season

Control/ Management

1) Prophylactic spray : A preventive spray with BM 1 per cent can also be given at the onset of monsoon in heavy rainfall areas.

2) Regular and frequent harvesting : Removal of infected pods at frequent intervals to reduce loss and

3) Fungicidal Spray : Spraying 1 % Bordeaux Mixture or 0.3 per cent copper oxychloride during monsoon twice at 45 days interval.

2) Charcoal rot (*Botryodiplodia theobromae* and *Macrophoma* Spp):

Season : More during summer, though it is seen through out the year.

Part affected : pods

Symptoms : Pods of all ages are susceptible. The affected pods turn black and remain hanging down on the tree as mummified fruit. Even beans inside the fruit turns black due to rotting of internal tissues. Soot (Charcoal/ black) of spore mass is formed.

Control: Spray 1 % Bordeaux Mixture.

Other diseases include cherville wilt, pink disease, white thread blight, etc.

Question bank

1. Botanical name of cocoa is ----- (*Theobroma cocoa*)
2. Large scale cultivation of cocoa in India started during ----- (1970's)
3. Write about microclimatic requirement of cocoa
4. Differentiate Criollo and Forastero types of cocoa
5. Write about the planting of cocoa as a mixed crop with coconut

LECTURE 32

Pests: Symptom of attack and control/management of i) Stem borer and ii) Mealy bugs.

Sl. No.	Name of the pest	Season of incidence and method of damage/ Symptoms	Management/ Control measures	Remarks
1	Stem borer (<i>Zeuzera coffeae</i> Nietn.)	Bores into the branches and trunks of cocoa trees.	Prune and destroy the affected branches and take up prophylactic spray to the plant with 1.7ml dimethoate or 2ml Quinolphos or 4g Carboryl per litre of water. It can also managed by local application of carboryl paste after pruning the affected portion of stem.	Caterpillars of this polyphagus pest commonly known as red borer or coffee borer
2	Mealy bugs (<i>Planococcus lilacinus</i> Ckll.)	Adult and young ones suck tender shoots, cushions, flowers and pods, etc. They also cause cushion abortion and wilting of cherelles. Season : More during summer.	:Spot application of 1.25 ml of monocrotophos or rogor 1.70 ml per litre of water. If there is recurrence of the pest repeat the application after 30 days	Most important pest of cocoa in India is mealy bugs.

Harvesting, fermentation and yield of cocoa.

Harvesting :

Flowering : 2nd year after planting

Flowering to pod development : 140 to 160 days

Stage of harvesting : Ripe pods without damaging the flower cushions.

Maturity symptoms :

- 1) Distinctive Colour : In foresterio green pods will become yellow when on ripening.
- 2) Rattling sound of beans : Seeds which are 25 to 45 in number rattle on ripening.

Harvesting intervals : 10 -15 days

Harvesting season :

Under South Indian conditions

- 1) September to January (Post monsoon)
- 2) April to June (Pre monsoon)

Off season crops are seen almost through out the year especially under irrigated conditions.

Note : Care should be taken not to damage flowering cushion at the time of harvesting of cocoa as it will produce the flowers and fruits of subsequent harvests.

Gap between harvesting and breaking of pods for processing : two days. (2-3 days). Break the pods cross wise and remove placenta along with husk and collect beans.

Pods can be kept upto a week before breaking and extracting the beans for fermentation.

Processing of cocoa :

Harvesting of cocoa consists of picking and breaking of ripe pods, removing the beans and transporting them for fermentation and drying.

Only ripe pods are harvested ----- Kept for minimum period of 2 days before opening the pods for fermentation (Should not be kept beyond 4 days). -----Break the pods -----collect beans for fermentation.

What for fermentation is essential in cocoa ?

Purpose of fermentation in cocoa includes;

- 1) To remove the adhering mucilaginous pulp,
- 2) To develop chocolate flavor and aroma precursors and to reduce bitterness,. Chocolate flavor is developed by the process of fermentation and drying at producer level and roasting them by manufacturer. The correct fermentation of cocoa beans is very important since, no subsequent process will correct the bad effect created at this stage.

3) To kill the germ (reproductive cells) of the seed and to loosen the testa.

4) To loosen testa and cause cotyledons to spread out.

Process of fermentation in cocoa:

It involves keeping the mass of cocoa beans immediately after taking out of the pods. Proper insulation for retention of temperature and adequate facility for aeration of beans and drainage the sweat liquor is given.

Process of fermentation lasts for about 6 days (in Forestero type) during which period the pulp or mucilage adhering to the beans dis-appear and cotyledons changes its colour. Eg. In Forestero colour changes from purple or violet to dark chocolate brown.

Methods of fermentation

Fermentation

Fermentation of Cocoa beans is essential to remove the mucilaginous pulp, to develop flavour and aroma precursors, reduce bitterness, kill the germ of the seed and to loosen the testa. Among the various methods adopted for fermentation in different cocoa producing countries, Heap, Box Tray and Basket methods are considered as the standard methods.



Heap Method

This method involves keeping a mass of not less than 50 kg. of wet beans over a layer of banana leaves. The banana leaves are spread over a few sticks to keep them a little raised over the ground level to facilitate the flow of sweating. The leaves are folded and kept over a heap of beans and a few wooden pieces kept over it to keep the leaves in position. The heaps are dismantled and the beans mixed the third and fifth days. It needs about six days for the completion of fermentation and the beans can be taken out for drying on the seventh day.

Even though the minimum quantity of beans required for effective fermentation is 50 kg. a further increase in quantity of beans in a heap will be beneficial. However, heaps of more than about 500 kg. may be difficult to handle.

Tray Method

Wooden trays of size 90 cm x 60 cm x 13 cm with battens or reapers fixed at the bottom with gaps in between, are filled with beans. Each tray can contain about 45 kg. wet beans. Six such trays are stacked one over the other and an empty tray is kept at the bottom to allow for drainage of sweating. After stacking, the beans of the top most tray are kept covered with banana leaves.

After 24 hours of setting the stack of trays is kept covered with gunny sacking to conserve the heat that develops. There is no need for mixing the beans and fermentation will be completed in four days. On the fifth day the beans can be taken out for drying.

The minimum number of trays required to be stacked is about six but as many as 12 trays can be used simultaneously.

Box Method

Wooden boxes of 1.2 x 0.95 m x 0.75 m with holes at the bottom and sides of the box are filled with wet beans. These boxes can hold one M.T. of wet beans. The beans are to be mixed on alternate days. As the quantity of beans is high, this is best done by changing the beans from one box to another at the time of mixing. This would necessitate having a minimum of three boxes.

Wet beans taken for fermentation should be sufficiently ripe so as to separate the beans from the polacuta and husk easily. Minimum quantity of wet beans for a normal fermentation is about 100 kg. The

duration of fermentation is commonly for 3-5 days i.e., 72-120 hrs. Fermentation over 120 hours will cause loss of chocolate flavour and development of off flavour.

Drying & Storage

The fermented beans can be dried either in the sun or by artificial means. Sun drying can be done in thin layers of 2 - 3 cm. depth and stirring from time to time. When the beans are dried properly, they produce a characteristic cracking sound on compressing a fistful of beans in the palm. The more scientific method is to use moisture meter. The dried beans after cooling maintaining 6 -8% moisture should be cleared before storage. The fruit broken, shriveled and other extraneous material are removed. The cleared bags are kept on a raised platform of wooden planks.

However, box and basket methods are recommended.

What ever be the method adopted care must be taken

- 1) Immediate fermentation : To put the beans for fermentation immediately after taking out of the pods.
- 2) Proper insulation : Fermentation mass need to be provided with proper insulation for retention of temperature
- 3) Proper facility for aeration of bean : Adequate facility for aeration beans must be made.
- 4) Drainage of sweat liquor.

Differences between box method and basket methods of cocoa fermentation;

Sl. No.	Particulars	Box method	Basket method
1	Minimum Quantity of beans required/Suitability	Large estates (40 to 100 kg)	Small quantity of beans (5 to 10 kg)
2	Method used	Wooden box of 60 cm x 60 cm x 45 cm with reapers at the bottom.	Bamboo or cane baskets of suitable size. Banana leaves at the bottom with provision for drainage of sweating.
3	Mixing process (To obtain uniform fermentation and to maintain temperature, moisture and aeration)	While transferring to next box after 24 hours	Mixed thoroughly on 3 rd and 5 th day

Yield: 20 to 35 kg ripe pods per tree or 100 - 131 pods per plant. Each pod will have 25- 45 beans. Dry beans per plant : around 2 kg In arecanut plantation the population per ha is around 686 plants and it will yield about 6q. dry beans per ha (i.e., about one kg dry beans per tree) High yielding clonal planting materials which have a production potential= 3 kg dry beans/tree.

Question Bank

1. Mention the major pests of cocoa
2. Mention the stage of harvesting and maturity symptoms in cocoa
3. Write about the purpose of fermentation in cocoa
4. Write a note on methods of fermentation in cocoa
5. Harvesting interval suggested in cocoa is ----- (10-15 days)

LECTURE 33

TEA

(*Camellia* sps) Family : *Camelliaceae* (= *Theaceae*)

Camellia sinensis L.

($2n = 30$)

Introduction :

Uses

- 1) As a beverage: Tea contains alkaloids called thein (2 to 5 %) which is a caffeinaceous alkaloid relieving body fatigue. However, excessive tea drinking is harmful to our digestive systems.
- 2) Polyphenols present in tea reduces blood cholesterol and cures hepatitis, hypertension, stone formation etc. (Heart attack is due to cholesterol + triglycerides which is a saturated fatty acid)
- 3) Medicinal properties: Black tea (a fully fermented tea) is anti ulceric and ant carcinogenic in nature.

Research Stations Board working on tea cultivation and in India

1. UPASI = United Planters Association of Southern India, UPASI Tea Research Institute, Nirar Dam B.P.O, Velparai – 642 127, Dist: Coimbatore, TN.
2. TES = Tea Experiment Station, Tocklai, Jorhat, Assam
3. **Tea Board:** Calcutta,

Origin and distribution of tea

Origin:

Chinese people were the first users of tea.

- South East Asia
- South Western China
- North Eastern India (Assam)
- Adjoining areas of Upper Burma (Myanmar) are probable place of origin of origin of tea.

The region from South East China (Szechwan-Yunnan) to Assam (India) has been reported as the centre of origin of the tea plant.

Now tea cultivation is extending from Argentina in the south (27 °S) to Georgia (Transcaucasia at 43 °N) and

From almost sea level upto 2,460 m MSL

Distribution of tea

World: Major tea growing area in the world (Nearly 93 %) is in developing countries.

Asia = 86 % of area and

Africa =8 % of total area (during 1986 %)

Asia: India, China and Sri Lanka are the main tea producing countries in the world.

India produces nearly 30 % of world tea production followed by

China (22 %) and

Sri Lanka (8%).

tea	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
China	1437873	9568	1375780
India	470000	17021	800000
Kenya	158400	19829	314100
Sri Lanka	221969	13064	290000
Turkey	75851	26183	198601
Viet Nam	111600	16639	185700
Indonesia	107000	14953	160000
Japan	47300	18181	86000
Argentina	39000	18826	73425
Thailand	18635	34186	63707

However China is having maximum area under tea in the world(over 40 % of world area) but the maximum production is from India mainly because of higher productivity (414 kg /ha in China compared to 1570 kg per ha in India during 1986)

Other countries:

Kenya (8 %) , Turkey, Indonesia, Japan, Mauritius, Bangla, USSR, Iran, Argentina, (Argentina at 27° S and Georgia (Southern part of USA) at 43° N

India:

In India 80 % of the area is above 50 ha in size and most of them are in corporate sector (United body)

North India = Nearly 80 per cent of total area in India,

South India = Nearly 20 % of total area in India

Distribution in India:

Assam = 53 %

West Bengal = 24 %

Tamil Nadu = 13 %

Kerala = 8 %

Other states = 2 % (It is from Karnataka, Tripura, Himachal Pradesh, UP, Bihar, Sikkim, Manipur)

Although Darjeeling produces the finest quality of tea, its productivity is low. The average yield in Darjeeling (635 kg/ha in 1981) is reported to be less than half of the all India average.

1) China bush: small leaved china bush,

Camellia sinensis L. var *sinensis* (Syn: *Thea sinensis*) commonly known as china tea. It is indigenous to China and cultivated in India, Nepal etc.

Features:

- 1) It is hardy, multistemmed, slow growing shrub or a small tree (1-6 m height).
- 2) Branches : Young branches are rather stout, hairy(hairy) to glabrous and older branches are grey.
- 3) Leaves : Small i.e., 4 to 10 cm long, erect, shortly stalked, elliptic, leathery, dark glossy green above and light green below.
- 4) Economical life : The variety has a economical life of about 100 years. However, pruning and continuous plucking reduces the life span.
- 5) Winter hardy : It can with stand severe winters and hot droughts on northern India. Hence, it is grown at an altitude above, 1050 m. Eg. Darjeeling.
- 6) Quality : It is highly valued for its flavor

2) Assam tea: Large leaved Assam tea have been recognized. = *Camellia sinensis* L. var *assamica* (Syn:*Camellia assamica*, and *Thea assamica*)

It is apparently indigenous to Assam, Mynmar, Thailand, Vietnam and South China.

Features:

- 1) Quick growing: It is quick growing tender plant of more southern distribution.

- 2) Stature: It grows into a single stemmed tree about 17 m in height if allowed to grow unimpeded.
- 3) Leaves: Larger leaves of 15 – 20 cm long usually thinner drooping leaves more or less acuminate at the apex, light green, glossy, puberulous chiefly along the mid rib below.
- 4) Economical life: It has a economical life of about 40 years.
- 5) Quality : The tea made from China plants have a definite character and flavour, but lack strength and quality which are marked in Assam teas when grown in certain areas
- 6) Distribution : Assam tea is used in North East India, South India, Sri Lanka, Indonesia, Africa and South America

Numerous hybrids between China and Assam types are known around Darjeeling in India. As tea is largely cross-pollinated and most of the commercial crop is raised from seed, the crop is very heterogenous.

3) Cambodia tea race

or Southern form of tea is closely related to *Camellia assamica* and is named *Camellia assamica* subsp *lasiocalyx*

Distribution: It is cultivated in the Nilgiris and in Western ghats near Mangalore and is commonly known as Southern form of tea or as the Cambodia race. It is a small tree with long narrow up-turned leaves. Base of the petiole is pinkish red in colour which is a distinctive feature of this variety.

Features

- 1) Stature : 4 to 5 m tall trees
- 2) Leaves : Hard and small (long narrow upturned leaves)
- 3) Yield: Poor yielder.

Different features of Assam tea and China tea.

Table: Differentiating features between Assam tea and China tea

Sl. No.	Features	Assam tea (<i>Camellia sinensis</i> var <i>assamica</i>)	China tea (<i>Camellia sinensis</i> var <i>sinensis</i> var)

			<i>sinensis</i>)
1	Stature	Tree	Shrub/bush
2	Branches and growth rate	Few robust branches and quick growing	Abundant branches and slow growing
3	Leaves	Large (15 to 20 cm long) and glossy and less serrated	Small (4 to 10 cm long), leathery and more serrated
4	Quality	Medium (better strength)	Good (Better flavor)
5	Yield	High yield	Low yield
6	Susceptibility to drought and frost	Susceptible	Hardy and resistant (Winger hardy)
7	Distribution	Countries near to equator viz., India, Sri Lanka, S.E. Assia, Central Africa etc	Cold countries and high altitude areas like Japan, N- Iran, S. Russia, or China <i>etc</i>
8	Economic life	Less (40 years)	More (Over 100 years)

Climate and soil requirement for tea

Climate:

Tea is a **subtropical** species.

In south India tea is grown in hilly areas and in

North India = Plains

Tea prefers a climate which is

- 1) Moist,
- 2) Warm and
- 3) Winter is not too cold

Temperature: Optimum = Mean maximum of 29.5 °C and mean minimum of 13 °C

South India vs North India

Tea is cultivated on hilly tract around 1000 m and above, the temperature is relatively low here where as in North India the temperature is high during summer on the plains, which is unfavourable for high tea productivity and a good stand of shade trees is therefore grown for optimizing productivity.

Altitude: It ranges from sea level upto 2460 m above MSL. In North India tea plantations are located in plains while in South India tea is cultivated in hilly terrain.

China tea is grown on higher altitudes.

Cardamom hills of South India = 2460 m above MSL

Rainfall: Well distributed rainfall ranging between 125 and 750 cm. In North Eastern India tea receives copious rainfall (150 to 500 cm). However, the distribution is most uneven.

The annual rainfall in South Indian tea growing areas varies between 90 and 800 cm.

Day length:

Critical day length for vegetative growth = 10.5 hours. It varies from 9.4 h to 15 h in North India

Where the tea growing area lies between 24 ° N and 28 °N latitude day length varies from 10 to 13 hours during different season

Winter = November to March = Shorter day length = Vegetative growth almost ceases

However, this is compensated during July to September (Summer) = Long and conducive to good vegetative growth.

In South India

Day length is = > 11 hours

Here tea growing areas lies below 12.5 °N latitude and characterized by minimal diurnal variation = Minimum day length not falling below 11 hours= Leads to uniform vegetative growth in tea throughout the year, except during the monsoon when productivity falls.

Relative Humidity

North India = High (> 60 %) throughout the year.

South India = Falls as low as 15 % in February to March. This necessitates protecting the nursery plants against desiccation with polythene cloches.

Frost: Causes adverse effect on tea bush, especially in the ravines.

Soil

Wide range of soils which are acidic in reaction. In North East India, the soils under tea range from the lightest of sands to the stiffest of clays and include silts and loams and even peat soils.

It prefers soils rich in organic matter with well drained situation.

It grows not only on hill slopes but also on low-lying flat lands as in some areas of North India, provided the soil is well drained. Some of the finest plantations in Assam are found on level ground. In Darjeeling where agroclimatic conditions are similar to those in the hilly tracts of western ghats and the Nilgiri hills in South India, tea is cultivated on **hill slopes**.

Calcifuge nature of tea

Tea is a calcifuge and an aluminium accumulator. Performance of tea in soils with higher Ca is not satisfactory. It grows on soils which are generally rich in iron and manganese.

Planting material and plant propagation in tea

I. Seed propagation: Seed is convenient to use as planting material in tea. Till today tea is generally propagated from seed.

But during recent years to use of high yielding clonal material = Hence Vegetative propagation. Tea is out breeding, and will not produce true seeds because of sterility. Genetically it is heterogeneous for potential yield, disease resistance and manufacturing quality.

Vegetative propagation:

Different vegetative propagation methods can be adopted in tea:

- 1) By budding
- 2) By grafting on rootstocks
- 3) By layering
- 4) By cutting = popular method of vegetative propagation.

Vegetative propagation by budding, grafting or by layering are too labourious to adopt.

Grafting: It is practiced for successful propagation of high yielding drought - susceptible clone used as scion on to drought - hardy clone used as root stock. In south India nursery grafts have been made using high yielding clones such as UPASI -3, UPASI – 8 and UPASI -17 as scions and drought hardy clones UPASI-2, UPASI-6, UPASI-9, UPASI-10 , UPASI-24, ATK-1, SA-6 and TRI 2025 as root stocks.

In view of the grafting success, survival, graft vigour of the composite plants and yield the following graft combinations have been recommended for commercial exploitation in southern India.

Vegetative propagation by cuttings:

Commercial method of propagation is through single node cutting (Semi hard wood cuttings is preferred method). Elite clone should be selected with desirable characters like yield, quality, quick recovery etc.,

Features of mother bush

- 1) Compactness: Number of stems per unit area should be high and should be uniformly distributed.
- 2) Individual stem should be thick and uniform.
- 3) Bushes should have early filling tendency.
- 4) Bushes should have lateral spreading habit.
- 5) Main stem and primary branches should have upright growth after pruning.
- 6) Density of Plucking point/units should be high.
- 7) Flushes/leaves should have pubescence.
- 8) Bushes should be resistant to blister blight and free from other pests and it should be drought tolerant.
- 9) High yield, Yield per unit area of plucking table should be high.
- 10) Flowering tendency: Selected bushes should not have flowering tendency.
- 11) Bushes should not have too many bhanji buds.
- 12) Secondaries and tertiaries in bush should have upright growth.

Selection of site and establishing tea plantation

New estate establishment: Clearing of forest growth by removing all unwanted plants and leaving only permanent shade trees. Take appropriate steps to prevent soil erosion. General burning is not advocated as it

- 1) Makes the soil alkaline and
- 2) Reduces the soil fertility

Note: If necessary burning is done away from the planting site.

Tea bushes will be having an economical life of over 40 years. While selecting sites following precautions should be taken;

- 1) Slopy land or hilly terrains or jungles: Take adequate soil conservation measures to protect soil erosion and also moisture conservation.
- 2) Soil: Acidic soil with adequate depth, good drainage etc.
- 3) Temporary shade trees: Shade has to be provided for young developing plants

Time of planting:

North India (Assam): Winter season with low rainfall but with plenty of mist is desirable i.e., October– November.

South India: Summer season (Rainy season) is most suitable time for planting i.e., May – June.

Planting operation

a) Pit size: Planting hole or trenches of 45 cm diameter and 60 cm depth.

Or pits of 30cm x 30cm x 45cm (depth) and if land is not good

45cm x 45cm x 45cm (depth) or

60cm x 60cm x 60cm (depth)

Spacing: Plant population of tea bushes vary from 14 to 18 thousands per ha. Higher plant population showed adverse effect after 4 to 5 years. Spacing varies from region to region and variety to variety

1.5 m x 1.5 m or

1.5m x 0.75 m = 14000 plants per ha closer spacing gives quick covering

1.2 m x 0.75 m or

1.2 m x 0.60 m = accommodates more than 16,000 plants per ha

Methods of planting

Single Hedge System

In this method, the spacing adopted is 1.20 x 0.75 m accommodating 10,800 plants/ha.

Double Hedge System

In this method, the spacing adopted is 1.35 x 0.75 x 0.75 m accommodating 13,200 plants/ha.

Training and pruning in tea

Normally tea bushes are established within a month after planting. Within a period of 12 to 18 months they reach a height of 60 – 75 cm (Field plucking stage) and after this stage pruning is taken up.

Pruning operations for bush formation

Framing and shaping = Training

Maintenance pruning = Production pruning

Duration from planting to regular plucking field stage = 18 to 20 months.

Initial operations: Initial post planting operations (Training) are designed

i) Centering : In South India, the leader stem is removed (Centered) at 20 to 25 cm from the ground level leaving 8 – 10 mature leaves on the plant. It is done to induce secondaries. When secondaries reach more than 60 cm, they are tipped at 50 to 55 cm height by removing leaves and bud to induce tertiaries. Further, training /pruning involves regular plucking with hand. This aims at getting an inverted dome or cone shaped bush.

Height of plucking table = 65 to 90 cm. It depends on the spacing, convenience for plucking and sustained yield for a considerable period without requirement of height reduction. Plant population adopted during recent years is about 15,000 per ha due to close spacing. **Height of plucking table varies from 65 cm to 90 cm.** The permanent frame should be established at an initial height of around 45 – 50 cm.

A frame of lower than 45 cm would

- ☹️ Create plucking problem and
- ☹️ Inadequate growth in thickness of stem.

Season of pruning: Pruning is carried out during the pre-monsoon or post-monsoon periods since adequate soil moisture is a pre-requisite for pruning.

Purpose of pruning in tea are:

1) Space utilization: Shaping trees to make the best use of space between trees. (15,000 plants per ha)

- 2) To induce vigor in growth/ to maintain plants permanently in vegetative phase: Re establishment of initial vigour of the shoot system to stimulate growth there by maintaining the plant **permanently in vegetative phase**. It stimulates the production of young shoots
- 3) To maintain the height of the plucking table: To facilitate convenient hand plucking of young buds with tender leaves and shoots at a cheaper cost. The plucking table continues to rise as the age from pruning advances and pruning assists in keeping the height of the bush within the bounds of easy and efficient plucking.
- 4) To remove interlaced (criss cross) branches, dead, diseased, knots and over aged wood. By doing this the bush will be rejuvenated.
- 5) To create congenial microclimate within the plant: Providing an environment within the plant which is conducive for maximum crop production but minimizes the spread of pests and diseases.
- 6) To maintain a balanced number of branches and sufficient volume of mature foliage to meet the physiological needs of the plant. There should be optimum balance between actively growing branches and foliage as to meet the physiological needs of plant. There should be an optimum amount of wood so that plants remain in a steady state of productivity.
- 7) Drought tolerance : Pruning helps in overcoming the drought effect; it also exposes the bark of frames which had been shaded for a few years.
- 8) **Maintaining the quality of tea** :by rapid renewal of flush suitable for manufacture of good quality tea.
- 9) To minimize pest and disease attack on tea bush.
- 10) To pluck maximum number of tea shoots/ leaves from convenient height.

Types of pruning: The criterion for determining the height of pruning should be the thickness of branches.

Generally, a 4-year pruning cycle is followed in the mid elevation areas and 5-year cycle at high elevations.

1. **Skiffing:** It is a lightest pruning. Here foliage is leveled off, only green stems are removed. Here top 5 – 8 cm new growth is removed so as to obtain uniform level of plucking surface. If the bushes are pruned about 75cm, it is referred to as skiffing. In plains of north-east India, tea is pruned every year when bushes enter the dormant phase. Though this method is no longer practiced, bushes are cut very lightly every year and this is called skiffing. Nowadays, certain estates do not do skiffing every year and leave the bushes unpruned for 2 successive years. At the end of the pruned year, the bushes may be skiffed deep, medium, light or level.

Skiffing may be repeated for 2-6 years. Deep skiffing is given at a height mid-way between pruning and tipping levels. In medium skiff, the cut is nearer to the tipping height, say 5cm below the tipping height/ Bushes which have been light or level skiffed are not tipped. The introduction of skiffing in place of pruning in north-eastern India has helped to increase the productivity. However, skiffed bushes are more prone to drought and they get heavily infested by pests such as ed spider mite and tea mosquito bug.

2. **Tipping:** It is the first round of harvesting of young shoots. Good frames could be developed with correct tipping. The first plucking of recovering bushes is called tipping. The objective of tipping is to establish a level plucking surface, to provide adequate maintenance foliage for the quick production of secondary branches.

3. **Lung pruning or fringe pruning:** Here criss cross branches are removed so that bush maintains a uniform height. Here all the leaves below the pruning level are left including peripheral branches. In this method dieback and death of plants is minimized.

4) **Medium pruning:** To check the bush growing to a inconvenient height this type of pruning is practiced. It stimulates new wood and maintenance foliage at lower level. It is done occasionally (once in 12 to 18 years). Medium style of pruning refers to pruning between 45 and 55cm.

5). **Rehabitation pruning or collar pruning:** 30 to 40 cm height. It is deep/heavy/severe pruning done to rejuvenate the bush when plants become uneconomical to maintain and grown out of hand. Here bush is cut off at ground level. Since this type of pruning is more severe casualties of plants may be high. A pruning height of 30-40cm is termed a hard prune when primary frames are healthy and if secondary branches have numerous knots and are cankered, a hard or medium pruning becomes necessary. In such cases, pruning is done into the secondary wood.

Question Bank

1. Mention about the research stations working on tea
2. Write about distribution of tea in India
3. Differentiate Assam tea and China tea
4. Critical day length for vegetative growth in tea is ----- hours (10.5 hours)
5. Write about the soil requirement in tea
6. Write a note on centering in tea

LECTURE 34

Shade maintenance and management in tea plantation

Tea requires filtered light and if it is exposed to direct sun its growth is affected. Tea bushes with semi – erect leaves don't require shade as the **leaves are not overheated when exposed and allow more light penetration into the bush**. Hence, the tea bushes with semi-erect leaves have highest yield potential as against the types with horizontal leaves. Broad leaved bushes perform better under shade. However, shade in tea has drawbacks like

Purposes of shade regulation in tea are (Beneficial effects of shade trees in tea cultivation)

1) **Protection:** To protect tea plants from direct sun and hot weather They help to reduce the injury caused to tea leaves by UV radiation.

2) **Fertility improvement:** Addition of organic matter in the forms of fallen leaves of shade trees apart from loppings obtained during shade regulation. About 20 to 25 tonnes of leaf litter is added per year out of shade trees. Increase the fertility of soil by adding 8-10 tonnes of organic matter/ha/year.

Note: 1) Fertility breakdown or degradation at 32° C is three times higher than at 16°C

2) For each 1 per cent increase in organic matter we have to add 22 t of organic matter per ha i.e., @ 2.2 kg per square meter.

3) **Breaking up of sub soil:** Shade trees break up the heavy subsoil layer due to root penetration.

4) **Temperature effect:** These trees help to regulate temperature and humidity at bush level

Summer: checks the raising of temperature of plantation during summer up to 5 to 7 °C compared to open. Day time they reduce the temperature and during night time increase the temperature by 5 to 7 °C compared to open.

5) **Wind breaks:** Shade trees serve as wind breaks

6) **Erosion control:** They also help in minimizing soil erosion.

7) **Additional income:** As timber, fuel, supporting tree for pepper etc

8) Decrease in pest incidence: Mite (*Acaris theae*) (Under shade 24 mites per leaf compared to 61 mites under open or unshaded leaves)

9) UV radiation: They help in reducing the injury caused to tea leaves by UV radiation. Shade trees trap 30-40 per cent of full mid day sun thereby minimizing the harmful effects of solar radiation.

10) Increased soil fertility: By adding 8-10 tonnes of organic matter per ha per year.

11) Regulation of humidity and minimized evaporation loss : Shade trees help to regulate temperature and humidity near the bush level apart from minimizing the loss through evaporation and transpiration.

Types of shade trees

Initial spacing of the shade trees may be about 6m x 6m which can later be thinned out to 12 m x 12m

Initially 6 m x 6m ---- reduced to 6m x 12 m at about 8-10 years age ---- reduced to 12 m x 12m at the age of 12 to 24 years age.

1) **Permanent shade trees** : Have similar longevity as that of tea and hence are planted during planting of tea. They are slow growers.

Spacing = 12 m x 12m

Eg : Albizzia spp (*A. odoratissima* and *A. stipulate*, *A. procera*, *A. moluccana* and *A. chinensis*. *Albezzia lebbeck* , silver oak etc)

Dalbergia sericea, *Dalbergia assamica*, *Derris robusta* etc

2) **Temporary shade trees** : Are fast growing trees planted to provide shade to tea plants during their initial growing period. Planting of temporary shade trees should be planned in such a way that, they will be 18 to 24 months old when the tea is planted.

Spacing: 6 m x 6m

Eg : *Indigofera teysmani*, *Glyricidia sepium*, *Leucaena glauca*, *Erythrina spp.*(*E. subumbrans* and *E. lithosperma* i. e., dadap for lower elevations is also used for shading purpose in south India) etc.

In south India (Nilgiri hills) silver oak (*Grevillea robusta*) is a shade tree of choice planted at 6 m x 6m and which can later be thinned out as required to 6 m x 12 m or 12 m x 12 m).

When permanent shade trees attain adequate height the temporary ones are removed by gradual lopping and uprooting.

Shade regulation in tea plantation: Shade trees should be lopped regularly to maintain the clear trunk upto the height of about 8 – 10m (singling).

Season of lopping: At the commencement of monsoon. Lopping of shade trees can be generally done twice a year at the commencement of monsoon. Trees of *Acacia* spp don't withstand lopping and hence need very light lopping. Shade trees in the beginning are

planted at 6m x 6m and later be thinned out by removing alternate trees as required to 6 m x 12 m or 12 m x 12 m spacing.

Manuring in tea

Economical part: Tender growing shoots

Hence, the recommendations are for

- 1) Suppression of reproductive phase and exploiting vegetative growth during growing season.
- 2) Balancing the harvest of growing paoings without affecting general health of bushes.

Normal dose of fertilizer for tea is

- ❑ Nitrogen = Ten kg of Nitrogen for every 100 kg of crop
- ❑ P_2O_5 = 30 to 40 kg
- ❑ K_2O = 40 to 50 per cent of amount of Nitrogen applied depending on soil type and weather conditions.
- ❑ **Manuring**
Manuring should be done 2 months after planting. Phosphorous should be applied at 80 - 100 kg/ha as Rock phosphate once in a year by placement at 15 - 25 cm depth up to the first pruning and thereafter once in two years. N : K ratio 2 : 3 should be adapted for the first 3 years and a ratio 1 : 1 thereafter.

Year of application	Total weight kg/ha/annum		No. of applications	Qty/plant (g)	
	N	K		Ammonium Sulphate	Urea
I year	180	270	5	13	27
II year	240	360	6	23	15
III year	300	450	6	29	18
IV year onwards	300	300	6	33	19

- ❑ Application of fertilizers should be done before the onset of monsoon. Fertilizers should be broadcast around the drip circle avoiding contact with the collar.

Plant protection in tea

Tea is grown as monoculture under varying agroclimatic conditions, remote from its natural environment. Hence, they are prone to the attack of many pests and diseases. Important ones are listed here under

Diseases of tea: Diseases due to fungi, bacteria, virus, animal parasites , physiological disorder and mechanical damages are observed.

Bacterial and viral diseases are not that problematic in tea when compared to fungal and algal diseases under Indian conditions

A) Leaf diseases

1) **Blister blight:** Cause : *Exobasidium vexans* (a fungal disease) :

2) **Black rot:**

B) Root diseases:

Blister blight disease of tea and its control

A) Leaf disease

1) **Blister blight:** Cause : *Exobasidium vexans* (a fungal disease) :

It is commonly found fungi in South India, Darjeeling and Assam but moderate in Himachal Pradesh. This disease is endemic to the growing areas of Asia. It has been reported from almost all tea growing regions of India. The disease is more severe in South Indian plantations than that of North East Indian tea plantations

Congenial conditions for disease spread : Cool, Moist an relatively still air favors infection.

Symptoms:

- 1) Presence of blisters on upper leaf surface & young shoots : Formation of circular or oval translucent spots. The spots become depressed forming a concave **blister** on the infected upper surface of leaves.
- 2) Convex under surface of leaves : Undersurface of leaves will produce convex surface and it becomes grey and finally white
- 3) Death of shoots :

Control measures:

Chemical control:

- 1) Application of copper fungicides i.e., COC @ 0.25 per cent.
- 2) Systemic fungicide: Calixin (Tridemorph 50 EC) best control. @ 1 ml per litre of water (0.1%).

3) Pruning schedule: Pruning operation should be shifted to dry weather period for minimum infection.

Harvesting (Plucking), Yield and Manufacturing of Tea

(Syllabus : Plucking, processing and yield of tea.)

Types of shoots in tea:

1) Aperiodic shoot / (Primary shoot) : From pruned sticks. Are the ones arising from the buds on the pruned frame/sticks. It produces large leaves and production of banji buds is only occasional.

When these aperiodic shoots or primaries grow above a predetermined height, they are cut or tipped. The branches of primaries are the first order laterals which when plucked give rise to the second order laterals. These again produce the third order laterals.

2) **Periodic shoots / Flush shoots/Crop shoots** : Arising from the axils of leaves. It constitutes the crop shoots. Periodic shoots exhibits cyclic pattern producing 7 -8 leaves (including scale leaves- fig -24 of Wealth of India book) in a cycle before terminating in a “Banji” whose growth and expansion ceases temporarily. When the crop shoot is harvested, generally the bud on the axil of the top most leaf of the stem develops into a new crop shoot.

Janams: The axillary bud, while unfolding, generally produces in succession two scales (first 2 scale leaves (cataphylls)), a small foliar structure in the shape of a thumb called Thumb leaf (also called Janam).

Fish leaf: A slightly larger but unserrated blunt leaf is designated as fish leaf (bigger thumb leaf). Above the scale leaves or janams is the smooth ‘fish leaf’.

Mother leaf: Fish leaf is followed by a series of three or four **normal foliage leaves**, first of which is called the mother leaf after which bahji is exposed.

Plucking in tea:

Plucking in tea :It consists of collecting the newly grown vegetative shoots i.e., Harvesting in tea involves the regular removal of young shoots comprising an apical bud and 2 or 3 leaves, immediately below it. Tea crop consists of terminal buds and two or three leaves just below with the stalk. The retention of adequate maintenance foliage for the continued health and productivity of the bush is necessary.

Stage/Age of plucking: Plucking stage is attained when tea plant is of 3 to 4 years old. However, plucking stage under ideal management conditions is attained in 18 to 20 months stage.

Young leaves with more of **tannins and polyphenols** produces better quality tea than old leaves with less tannin content. Maximum yields (stable/economical stage of yield) are obtained in 6th or 7th year and there after the yields remains constant.

Type of shoot/ Leaves/Bud	Tannin (%)
Bud	25
I leaf	28
II leaf	21
III leaf	14
Stalk between II leaf and bud	12
Stalk between II and IV leaf	6

It is clear that, plucking of the terminal bud only or with terminal bud with I leaf gives excellent quality tea. Bud is usually plucked with I and II leaves. (i.e., **Best plucking is two leaves and a bud**)

Kinds of plucking depending on the extent of maturity of shoots

Young leaves with more tannin and polyphenol content produces superior quality tea.

- 1) Two and a bud: plucking of terminal bud and two most recently opened/expanded leaves. Two leaves and a bud is considered as one plucking unit. Two and a bud is called fish leaf or Janam flucking.
- 2) Fine tea: Anything less than two and a bud. It is also known as fish or janam plucking. Young leaves will produce superior quality tea.
- 3) Coarse tea: Anything more than two and a bud. Older leaves will produce coarse quality tea.
- 4) Light plucking or light pruning: Carried out during initial years to encourage side branches and to make the bush full with tender branches.
- 5) Too tender shoot/One leaf and a bud: Produces very good quality tea but yield goes down drastically.

Shoots may be plucked above janam, fish leaf or mother leaf. These system of plucking are known as janam plucking, fish leaf plucking or mother leaf plucking, respectively.

- ♣ In north-eastern India, janam plucking is the most common practice.
- ♣ In south India, continuous scale leaf or fish leaf plucking is not adopted.

Time of plucking: Better quality tea is obtained from the shoots plucked in the morning than in the evening hours.

Morning: More soluble proteins are present and produces good quality tea.

Afternoon: Insoluble proteins will be increased.

Night: Break down of amino acids and formation of amino acids

South India

In south India, plucking differs from that of north-east.

The climatic conditions in south India force growth into 2 impulse periods (High cropping /Rush cropping) where in 60 per cent of the total crop is harvested at an interval of 7 to 10 days.

i.e.,

1. From April to June and
2. From mid-September-November. About 60% of the total crop is harvested in this period and availability of workers becomes a serious constraint to invest the crop completely. Plucking is to Janam or fish leaf.
3. **Low cropping /lean cropping:** July to September (Rainy season) and January to March (Winter) = About 40 % of the crop is harvested at an interval of 12 to 15 days.

Cost of plucking:

Plucking is normally (Most of the tea grown throughout the world) done by hand by woman or children. Major drawback in mechanizing the harvesting process in tea is the steep and irregular slopes on which tea is very often grown

Plucking in tea accounts for

15 to 20 % of total production cost and

60 to 70 % of total labour involved in tea estate.


Use of hand held shears: It is now recommended to use handheld shears to harvest the crop during these high cropping seasons. Use of shears is advised only to the high cropping periods and that too for fields which are **more than 18 months old from pruning**. Continual shear harvesting is proved to depress the crop and adversely affect the bush physiology.


Life span of tea bush:

Stage/Age of plucking: Plucking stage is attained when tea plant is of 3 to 4 years old. However, plucking stage under ideal management conditions is attained in 18 to 20 months stage.

Maximum yields (stable stage of yield) : are obtained in 6th or 7th year and there after the yields remains constant.

Economical life of bush:

 **North East India:** 40 to 50 years, though there are individual bushes surviving as many as 200 years.

 **South India :** 80 years or even more

Yield

Yield of made tea: 20 to 30 q per ha

20 q /ha = Low yield

20 – 30 q /ha = Medium yield

> 30 q/ha = high yield

Manufacture of tea \ processing of tea

Tea contains 4.5 to 5 % Nitrogen compounds $\frac{3}{4}$ of which can be attributed to proteins and amino acids and $\frac{1}{4}$ to alkaloids. Chief alkaloids are thein , theobromine and theophyllomine.

*** Maximum caffeine content allowed is 3 %**

Classification of tea (Based on the method of manufacture in general and the extent of fermentation i.e., enzymatic oxidation in the true sense)

1) **Green tea:** produced without fermentation. Green tea is un-withered, unfermented tea prepared by drying tea leaves either by steaming or passing hot air over leaves. Unlike in

black tea in green tea enzymes are destroyed by steaming or blowing hot air avoiding fermentation. The final product is green in colour.

2) Black tea: Fully fermented. About 73 per cent of global out put is black tea and

3) Oolong tea: partially fermented

Several types of commercial teas are known such as

☞ Black,

☞ Green, these two (Black and green) is processed to a maximum extent in India.

☞ oolong,

☞ brick and

☞ Let- pet teas.

Each of teas has its own characteristic aroma and taste.

Oolong, brick let-pet and other types of tea are manufactured chiefly for export and on experimental scale.

Basically there are three types of processing in tea (Based on the method of rolling in the preparation of black tea).

1) Orthodox method: Rolling operation is done in a series of rollers (i.e., based on the traditional method)

2) CTC (Crush, Tear and Curl) method: It has a CTC machine consisting of series of a pair of rollers adjusted to crush and tear leaves.

3) LTP (Laurie Tea Process (LTP): LTP is essentially a pulverizing machine. It carries many sets of beaters.

In the preparation of black tea, four principal operations are involved viz., (a) withering, (b) rolling, (c) fermenting, and (d) drying.

Irrespective of the method of manufacturing tea it involves following steps

Manufacture black tea either by the CTC (Crush, Tear and Curl) or the orthodox method involves steps viz.,

1) **Withering:** Moisture content of leaves is reduced (to about 55 %) by drying in a trough receiving artificial air. Duration of drying varies from 12 to 18 hours.

2) **Rolling:** During rolling cells of leaves are broken to liberate sap containing polyphenol oxydase (and enzyme). Rolling takes place for about 30 to 40 minutes.

- 3) **Fermentation:** Rolled tea material is spread on concrete floor or trays under high humidity and proper temperature to undergo fermentation. Properly fermented tea will attain **golden red colour** deciding the quality of tea. Theaflavins: and Thearufigns are compounds responsible for colour of tea.
- 4) **Drying:** Slow reduction in moisture content as to stop fermentation process. Moisture content is reduced to **about 4 per cent**. Duration of drying is for about 30 to 40 minutes.
- 5) **Cleaning & grading:** Remove stalky fibers and grade the tea by passing through different sized meshes.

1) **Withering:** The first step in processing of black tea is withering.

The main **objective** of withering is

- 1) Reduce moisture content of tea leaves: It lowers moisture content to about 55 per cent (by removing 15 to 20 % moisture). During this the leaves undergo physical and chemical withering. Leaves are withered in troughs for about 12-18 hr.
- 2) When leaves have been withered correctly, it becomes flaccid and suitable for rolling during which polyphenols are mixed with enzyme **polyphenol oxidase (PPO)**.

Judging the end point of withering

- ♣ **No cracking sound:** Well withered leaves will not produce any cracking sound when squeezed i.e., it must not be too dry.
- ♣ **Compact ball:** Withered leaves when pressed by hand should form compact ball.
- ♣ **No brittle stalk:** The stalk of the withered leaves should not be brittle.
- ♣ **Feel test:** Withered leaves will have silk hand kerchief feel to touch.

Withering may be of

- 1) Natural or Chung withering: 18 to 20 hours
- 2) Artificial withering: 3 to 4 hours.

Some chemical changes, besides loss of moisture, also take place during withering.

a) **Chemical changes:** A slight increase in caffeine and a relatively large increase in some of the amino acids are the earliest chemical manifestations. The extent of chemical changes in

the tea is more in natural wither, less in artificial wither and least in wither under humid conditions.

b) Quality: The chemical changes during withering and the degree of wither of tea shoots are partly responsible for the **liquor characteristics, physical appearance** and **overall quality** of the made tea.

Black tea: Withering is not considered essential for the manufacture of black tea although it does have an influence upon the appearance and quality of the finished product.

2) Rolling:

Leaf damage: The withered leaf is passed on to rollers where it is twisted so as to cause sufficient damage to the individual leaf cells and to initiate enzymic oxidation.

1. Duration and extent of rolling : Rolling is usually done for 30 minutes and the rolled mass is sifted and the finer portions of the leaf are allowed to ferment
2. While the coarser portions are subjected to heavy rolling. Rolled for 3 to 4 times.
3. Sometimes a third rolling may be given; rolling is essentially a batch operation. Due to rolling the **catechins** (Polyphenol) are thoroughly exposed to the polyphenol oxidase. (PPO)

Three major manufacturing methods commonly used are

- i) **Orthodox.**: Which employs non-cutting rollers. The orthodox tea has superior flavour but poor in colour.
- ii) Crushing, tearing and curling (CTC) which employs rotoravanes and cutting rollers. CTC tea is more economical with red colour and popular in India and

3) Fermenting (enzymetic oxidation) – Actually fermentation starts /commences at the time of rolling and continues till the entry into the driers.

The main operation in the manufacture of black tea is **enzymatic oxidation** which was originally termed fermentation and the term is still in vogue today. In tea processing, fermentation is the term employed to denote enzymatic oxidation, by which the polyphenols in the leaf get oxidized with the help of PPO (Polyphenol oxydase).

Method of fermentation : The coarse and fine fractions of the rolled leaf are spread on clean cement floors or other suitable platforms to a thickness of 2.5- 10.0 cm depending upon the season and condition of the leaf, and allowed to ferment for 2-4 hours depending upon the type of roller used.

Two types of compounds are formed during fermentation process.

- 1) Theaflavins (TF) === **Orange red.**
- 2) Thearubigins (TR) === **Darker brown.**

The quantity of TR and TF formed will be related to the period of fermentation and the temperature of fermenting leaves.

4. Drying or Firing





Objective of drying is to arrest fermentation.

Moisture of the made tea: The dried product contains **3-4 percent** moisture, and can withstand long storage and transit

5) Sorting and Grading -

The black tea is sold loose or in packets, under different brand names.

Stalk is removed during sorting. There are four main sizes, viz.,

-  I. whole leaf,
-  II. brokens,
-  III. fanning's and
-  IV. Dusts.

Packing and grading in tea:

Dried tea is cleaned of stalk fibres (petioles/stalks/fibres) by passing through fiber separating machines.

Bulk tea is passed through different meshes which aid in separation into different grades;

Question Bank

1. What are the beneficial effects of shade trees in tea?
2. Write a note on blister blight disease in tea
3. Young leaves produces better quality tea – Justify
4. What do you mean by Green tea and Black tea?
5. Mention the various steps involved in manufacture of black tea

6. Partially fermented tea is ----- (Oolong tea)
7. CTC in tea processing stands for ----- (Cutting Tearing and Curling)
8. Compounds responsible for colour development in tea are ----- and -----
(Theaflavins and thearubigens)

