Coconut

Coconut (*Cocos nucifera* L.)

Family: Palmae

The coconut palm provides a variety of useful products like food, fuel and timber. Every part of the tree is being utilized for some purpose or other and hence, it is called **Kalpavriksha** meaning **tree of heaven** which provides all the necessities of life.

Origin and distribution: Origin - South East Asia.

Distribution of coconut

World:

Indonesia, Philippines, India, Sri Lanka, Thailand, Malaysia, Papua New Guinea, Fiji etc.

India:

Kerala, Tamil Nadu, Karnataka, Andra Pradesh. Kerala stands first in India in area and production of coconut while productivity is highest in Andhra Pradesh

Botany

It is a tall, stately unbranched palm growing to a height of 12 to 24 m. The trunk is stout, flexuosus, annulate, rarely stands vertically, but makes a gradual curve, rising from a swollen base surrounded by a mass of adventitious roots. The stem is marked by rings of leaf scars, which are often not prominent at the base.

The coconut palm has an adventitious root system of monocots producing numerous thick roots from the base of the stem almost throughout its life. The roots are localized generally at the lower most region of the stem, which has been termed the ‘bole’.

Leaves large, long pinnatisect, borne on the crown; leaf-lets equidistant, 60 to 90 cm long, narrow, tapering, linear, lanceolate, coriaceous, flaccid; petioles stout, 90 to 150 cm long.

Spadix is 1.2 to 1.8 m long, stout, erect, straw or orange coloured, androgynous, simply branched, branches (spikes) bear one or more female flowers often between two male flowers towards their bases, and several males above; spathes 2, outer short, inner 60 to 90 cm long, oblong hard, splitting lengthwise. The palm is monoecious with female flowers relatively a few, male flowers are numerous, small, unsymmetrical, sweet scented; sepals small, valvate, petals about 6.4 mm long, oblong, acute, valvate; stamens 6, filaments sabulate, anthers about 2.5 cm long, globose, bracteolate, perianth greatly acrescent, round, concave, imbricate petals are shorter than the sepals, convolute with imbricate tips; disc annular. Ovary is tricarpic, usually one ovuled sub-basilar.

Fruit is large 20 to 30 cm long, trigonolly obovoid or subglobose, three sided, and drupe one seeded. The outer layers of the pericarp are thick and fibrous. The inner layer (endocarp or shell) is very hard, horny or stone with three basal pores or marks representing the remains of 3 carpels or the loci of the ovary, two of which have become obliterated. Under one of these, lies the embryo. The thin testa cohering to the endocarp is lined with white albuminous endosperm (meat) enclosing a large cavity, partially filled with sweet fluid.

Climate and soil

The coconut palm is found to grow under varying climatic and soil conditions. It is essentially a tropical plant. The palms tolerate wide range in intensity and distribution of rainfall. However, a rainfall of about 200 cm per year and well distributed throughout the year is the best for proper growth and maximum yield.

Coconut is adaptable to a wide range of soil conditions, from light sandy soils to heaviest clays with a pH ranging from 5.2 to 8.0.

Cultivars and hybrids

Coconut palms are broadly classified into two groups, the tall and dwarf. The tall cultivars are the common types that occur throughout the world. The tall cultivars largely grown in India are the

1) West Coast Tall 2) East Coast Tall.
3) ALR (CN-1)
4) ALR (CN-2)
   - Parentage - Selection from Tiptur Tall
   - Yield - Average Yield: 109 nuts/palm /year
   - Annual yield: 18988 nuts/ha/year
   - (12 % over ECT and 99% over VPM 3) **Special features**
   - Nut bearing in 5½ years
   - Regular bearing habit
   - 12 inflorescences per year
   - Weight of copra - 135 g/nut
   - 2.57 tonnes of copra per hectare
   - 7400 nuts required to make one tonne of copra
   - Oil content 64.7 percent
   - Possesses drought tolerance
   - Moderately resistant to rhinoceros beetle, red palm weevil and leaf blight
5) VPM 3
   - Parentage – Selection from Andaman Ordinary
   - Year of release – 1994
   - Annual nut yield / palm – 92

   Special feature
   - Tall variety
   - 63 months for first flowering
   - Big oblong nuts

- Oil content 70%
- Copra content 176g/nut
- Drought tolerant

The common dwarfs available in India are

1) Chowghat Orange Dwarf
2) Chowghat Green Dwarf
3) Malayan Green Dwarf
4) Malayan Yellow Dwarf
5) Malayan Orange Dwarf
6) Gangabondam

Which are generally grown for tender nuts. The hybrids between Tall and Dwarf forms (TxD) or vice Versa (DxT) show hybrid vigour for growth, earliness and yield.

Hybrids

1) WCT x COD,
2) COD x WCT (Chandra Sankara)
3) **VHC1**
    - Parentage – East Coast Tall X Malayan Green Dwarf
    - Year of release – 1982
    - Annual nut yield / palm – 115

    Special feature
    - T X D hybrid
    - 40 months for first flowering
    - Oblong nuts
    - Oil content 68.6%
    - Copra content 142g/nut **4) VHC2**
    - Parentage – East Coast Tall X Malayan Yellow Dwarf
    - Year of release – 1988
    - Annual nut yield / palm – 142

    Special feature

- T X D hybrid
- 43 months for first flowering
- Medium to big oblong nuts
- Oil content 70.2%
- Copra content 146g/nut **5) VHC3**
- Parentage – East Coast Tall X Malayan Orange Dwarf
- Year of release – 2000
- Annual nut yield / palm – 156

Special feature

- T X D hybrid
- 46 months for first flowering
- Medium to big oblong nuts
- Oil content 70.2%
- Copra content 162 g/nut

Selection of mother palm

In the selection of mother palms, the following characters are looked for:

1) The palm should be a regular bearer and should give an annual yield of about 60 nuts under rainfed condition. The copra content per nut should be around 150g.
2) The crown should be spherical or semi-spherical drooping or erect crown should be avoided, and should have at least 30 freely opened leaves.
3) The length of petiole and bunch stalk should be short and stout.
4) The nuts should be medium in size and nearly round or spherical or oblong.
5) The bunches should have a preponderance of heavy nuts.
6) The trees producing barren nuts should be discarded.
7) The palms should be between the age group of 25-60 years.

8) The palms growing close to house, cattle sheds, compost heaps water holes etc. may be avoided as it is difficult to identify inherently good trees.

Preparation of land and planting

Normally a pit size of 1.0 x 1.0 x 1.0 m is dug and filled upto 50 cm depth with sand and powdered cowdung.

Spacing

A spacing 7.5 to 9.0 m may be adopted depending on the crown size. This will accommodate 177 to 124 palms per ha under the square system of planting. In well drained soils, seedlings can be transplanted with the beginning of southwest monsoon. If irrigation facilities are available, it is advisable to take up planting at least a month before the monsoon sets in so that the seedlings get well established before the onset of heavy rains.

Care of young palms

The transplanted seedlings should be shaded and irrigated properly especially during the summer months. The pits should be cleared of weeds periodically. Soil washed down by the rains and covering the collar of the seedlings should also be removed. The pits should be gradually filled up as the seedlings grow.

Manuring

As coconut yields throughout the year it takes heavy amount of nutrients from soil especially N, K and Cl. Therefore, regular Manuring from the first year of planting is essential to ensure good vegetative growth, early flowering and bearing and high yields. The fertilizer requirements of different coconut growing states are given below:

1 From 5th year onwards, apply 50 kg of FYM or compost or green manure. 1.3 kg urea (560 g N), 2.0 kg super phosphate (320 g P2O5) and 2.0 kg muriate

of potash (1200 g K20) in two equal splits during June – July and December – January. Apply manures and fertilizers in circular basins of 1.8 m from the base of the plam, incorporate and irrigate. During 2nd, 3rd and 4th year ¼, ½ and ¾ doses of the above fertilizer schedule should be adopted respectively. Sufficient moisture should be present at the time of manuring. Fertigation may be done at monthly intervals with 75% of the recommended dose of the above fertilizers. Phosphorous may be applied as super phosphate in the basins and incorporated or as DAP through drip when good quality of water is available.

TNAU Coconut tonic

For nut bearing coconut, root feed TNAU coconut tonic @200ml/palm once in six months.

Bio-fertilizer recommendation

Mix 50 g of *Azospirillum*, 50 g of Phosphobacteria (or) 100 g *Azophos* and 50 g of VAM in sufficient quantity of compost of FYM and apply near feeding roots once in 6 months / palm starting from planting. Don't mix with chemical fertilizers and pesticides

Organic recycling

Any one of the green manure crops like sun hemp, Calapagonium or Daincha may be sown and ploughed *in situ* at the time of flowering as a substitute of compost to be applied. Sow sun hemp @ 50 g/palm in the basin and incorporate before flowering. Coir pith compost/vermicompost made from coir pith /coconut leaves / other wastes from coconut grove can be applied.

Irrigation

The coconut palm responds to summer irrigation. Production of female flowers and setting percentage increases considerably due to irrigation, 2 cm irrigation

once in 4-5 days during December-May is beneficial in sandy loam soils. Coconut husks or dusts can be added in pits to conserve moisture.

Inter cultivation

Tillage operations like digging the garden with mammutty (spade), ploughing are beneficial to the trees. Method of intercultivation will depend upon local conditions, availability of labour, size of holding, soil type, topography and distribution of rainfall. Cover cropping is recommended to prevent soil erosion in coconut gardens. Leguminous crops such as ***Mimosa invisa, Stylosanthes gracilis*** and ***Calapogonium mucunoides*** are generally recommended. Green manure crops like sun hemp **(*Crotolaria juncea*)** and ***kolinji* (*Tephrosia purpurea)*** are also raised and ploughed in during AugustSeptember.

Inter and mixed cropping

A variety of intercrops like pineapple, banana, elephant foot yam, groundnut, chillies, sweet potato and tapioca can be raised in coconut gardens after the palms attain a height of 5 to 6 metres. In older plantations, cocoa, pepper, cinnamon, clove and nutmeg can be grown as mixed crops.

Harvesting

Harvesting is done at 45 days interval during summer months and at 60 days interval during the rainy season. Hence, 35 percent of the total nut is obtained during the hot months i.e., from March-May and least crop is obtained during rainy months. Harvesting is done by climbing the tree.

Yield

60-80 nuts per palm per year

Special Problem

Shedding of buttons and immature nuts and production of barren nuts

These are some of the important problems of coconut cultivation, which adversely affect the yield to a large extent. The probable causes which may be attributed are the attack of pests and diseases, nutritional deficiencies, unfavourable soil and climate conditions, defects in pollination and fertilization and the limited capacity of the tree to bear fruits.

Production of barren nuts

The phenomenon of the occurrence of barren nuts (without or with imperfectly developed kernel) is as ancient as the cultivation of coconut. From the detailed investigations carried out on this problem at Kasaragod, Kerala, it was revealed that in the coconut plantations certain trees produce a large number of barren nuts. The nuts are generally oblong in shape and the quality of husk produced is very much less as compared to the normal ones. The embryo in the barren nuts is mostly absent or when present, it is in varying stages of decay. Often, these nuts are seen with the shell and kernel improperly developed. Fungal infection is also sometimes noticed in the embryo, resulting in the decay of the kernel and loss of water inside. Of the different types of barren nuts met with, those with cracking of shell are relatively more common than the other types.

Preliminary trials carried out at the Central Plantation Crops Institute Research, Kasaragod, revealed that barrenness could be induced by keeping female flowers unfertilized indicating thereby that defective fertilization may be one of the possible causes of barren nut production. Preliminary work done at Kasaragod to determine the possibility of reducing the incidence of barren nuts through heavy manuring with 2.722 kg ammonium sulphate, 1.814 kg of bone meal, 27.215 kg ash and 90.718 kg of green mature per tree failed to show any distinct beneficial effect. Genetic causes are also attributed to button shedding. Although investigation made on the phenomenon failed to establish conclusive reasons for the occurrence of barren nuts. It is not however, improbable that excessive bearing may be one of the causes.

Plant protection

The major pests and diseases affecting the coconut palm are furnished below:-

Pests / diseases	Control measures
Rhinoceros beetle (*Orycetes rhinoceros)*	Proper disposal of decaying organic debris extracting the beetle with a hook mechanically, filling the inner most three or four leaf axils of palm with a mixture of 5% BHC dust and sand (1:1), three times a year.
Red Palm weevil *(Rhynchophorus ferrugineus)*	Injection of Pyrethrin piperonyl butomide (PyroconE) 10ml in one litre of water per palm into the trunk through a hole above the infested portion.
Diseases	
Bud rot *(Phytophthora palmivora)*	Application of Bordeaux paste in the cut portion of the infected tissues at early stage of infection itself.
Root (wilt) diseases	
Thanjavur wilt *(Gonoderma lucidum)*	Apply 5 kg of neem cake per year; addition of organic matter, providing irrigation could check the spread of disease.

Value added Product

Coconut is the most beautiful and useful of palms known to mankind. Coconut is unique, producing a host of products. Presently India is having an area of 18, 95,000 ha with production of 15,730 million nuts. (INDIAN

HORTICULTURAL DATABASE, 2010)

Products of coconut can be broadly classified into 3 categories. They are: food products, commercial products, coconut shell and miscellaneous products (Rethinam *et al*., 2002). Farm level processing either individually or collectively can result in higher income. When coconut is converted to milling copra there is value addition of about 25% and into edible ball copra it is 3540%. Value addition is nearly 22% by marketing tender nut in place of mature nut.

Coconut milk powder

Two types of health mixes can be prepared from coconut milk powder viz., therapeutic health drink and malted health drink. For therapeutic health drink, initial content of chemical constituents like moisture, protein, energy, fat, fiber, calcium, phosphorus, iron, free fatty acid and peroxide value were 7.68%, 9.12 g, 335 Kcal, 1.8 g, 1.39%, 430 mg, 222 mg, 1.76 mg, 0.23%, 0.39 meq respectively / 100 g of product and for malted health drink were 9.09%, 15.66 g, 323 Kcal, 2.9 g, 1.62%, 566 mg, 219 mg, 1.95 mg, 0.32%, 0.54 meq respectively / 100 g of product. Cost of 100 g of health mixes is Rs. 25/- (Kutty *et al.,* 2004).

Coconut syrup

Coconut syrup is prepared by adding an equal quantity of sugar and 0.05% citric acid to coconut milk, followed by steam-cooking to a total solids content of 65-68%. It is used as a drink and a bread-spread.

Coconut honey

Coconut honey is prepared in similar way from coconut milk by adding brown sugar and glucose.

Desiccated coconut

It is the dried, disintegrated coconut meat of fully matured nut stored for a month before de-husking. This makes de-shelling easier and whole kernel is removed

from shell. Brown testa covering the kernel is removed and then kernel, washed, sterilized, disintegrated and desiccated at 77-82°C to a final moisture content of 2-2.5%, followed by cooling.

Coconut flour

Coconut grating from which fat is removed partially by hydraulic pressing or fibrous residues after extracting milk are dried and powdered to obtain coconut flour. Coconut flour contains 31% carbohydrate and 43% fibre.
It is utilized in bakery and confectionery products.

Dietary fibre

Spent coconut residue is a good source of dietary fibre especially insoluble fibre. High fibre content especially insoluble fibre offers scope for its utilization as a dietary component against constipation, obesity and for diabetic patients (Rastogi and Raghavarao *et al.,* 2006). Sensory quality of products prepared out of dietary fibre *viz.* biscuits, coconut burfi, coconut chutney (dry), sambar and traditional Indian sweets) was good and overall acceptability was very high. Substitution of rice by 10% with coconut flour in dosa and wheat by 20% in chappatis has got acceptability (Ramaswamy, 2006).

Toddy Products

Toddy is a sweet juice containing sucrose as the main constituent obtained by tapping unopened spadix. Dwarf palms are highly suitable for tapping due to their short stature and toddy is sweeter but yield is less than tall palms. Tapping toddy increases yield of poor-bearers.

Fresh toddy, if not collected under sterilized conditions, is fermented rapidly. Sugar turns into alcohol (5.8%) and product collected by distillation is strong liquor known as Arrack. Other products obtained are jaggery and refined sugar by evaporation and coconut vinegar by fermentation of toddy.

Virgin coconut oil

Virgin coconut oil is naturally processed product of fresh coconut meat (kernel) either directly or through extraction of coconut milk. It is colourless (water white) and has a mild to intense coconut scent and is rich in lauric acid (47-53 %). It also contains vitamin E (tocopherols) at 5 mg / kg. Virgin coconut oil in its pure form can be directly consumed and has a mild, sweet scent. It is an excellent and exotic salad dressing, a good food seasoning and serves as healthy cooking oil because it is highly resistant to heat. This also has wider uses in functional foods, pharmaceuticals and cosmetics.

Coir and coconut fibre

It is an important product obtained from fruit husk. Husk forms 35-45% of whole nut when ripe of which 30% constitutes coir fibre and 70% are pith and outer skin. Lignin and cellulose are the major constituents of pure fibre.
There are 2 types of fibres, white fibre and brown fibre.

White fibre

It is extracted from green husks after retting in natural water for 6-10 months until fibre becomes loose and soft. When facilities for natural wetting are lacking, it can be subjected to mechanical decortication and extraction. Nuts of 11 months old are best suited for extraction of white fibre. White fibre is long and fine, suitable for spinning into coir yarn for making ropes and mats.

Production is mainly confined to Kerala.

Brown fibre

Brown fibre is extracted from ripe dry husks by mechanical de-fibring process. Two types of brown fibre are bristly fibres and mattress fibres. Bristly fibre is short and used for making brush, whereas mattress fibre is long and used for stuffing purpose in upholstery and mattress.

Coir pith or dust

A waste product of coir industry known as cocopeat, it is used as a mulch, for making briquettes with high calorific value, as a manure after composting with 'pith plus' a formulation containing *Pleurotus sajor caju*. It can also be used for production of biogas, lightweight building bricks and as a soil conditioner.

Coconut shell-based products

Coconut shell powder prepared from matured shell is preferred to other similar materials like wood bark powder because of its uniformity in size and chemical composition. Shell charcoal prepared by burning shell in limited supply of air finds application in plywood and laminated boards as a phenolic extruder, and filler in synthetic resins, mosquito coils and agarbathi industry. Shell charcoal has extensive demand in manufacturing of activated carbon which is considered superior for gas absorption due to small-pore size and high mechanical strength.

Arecanut (*Areca catechu)*

Arecacaae (Palmae)

Origin: Malaya, Phillipines, East Indies

Distribution: India, Bangaladesh, Sri Lanka, Indonesia, Malaysia.

Area	**Production**
World -5.88 lakh ha	7.27 lakh tons
India- 3.00 lakh ha	4.78 lakh tons

In India it is cultivated in Maharashtra, Karnataka (50%), and Kerala, Assam etc.

Uses:

- Masticatory
- Chewing along with betel leaves & tobacco
- Increase the production of saliva and gastric juices.
- For treatment of leucoderma, leprosy, cough, fits, anaemia, obesity etc.
- Being a source of tannin, it is used for dyeing clothes and tanning leather.
- Used for manufacturing plastic, hard boards etc.
- Leaf sheath is used for manufacturing ply boards, picture mounds, use and throw cups and plates.

Botany:

Unbranched erect growing palm, height 60-70 ft., stem is smooth with scars of fallen leaves. Has 60-100 leaves partly fused and partly free.

Inflorescence is a spadix with male and female flowers. Monoecious, fruit set 30%.

Cultivars: Mangala, Sumangala, Sreemangala.

Mangala- Semi tall, early bearing (3 years after planting) high nut set, good chewing quality.

Sumangala- Tall variety, medium sized oval shaped nuts, high percentage of chali recovery.

Sree mangala- compact bunches with bold and round nuts.

Variety	**Country of introduction**	**Year of release**	**Ripe nut yield Kg/Palm**	**Chali(Dried kernel) Kg/palm**

Mangala	China	1972	8.82	2.02
Sumangala	Indonesia	1985	12.9	3.3
Sree mangala	Singapore	1985	12.8	3.1

Other varieties:

Variety	**State**	**Chali yield (Kg/palm)**
Mohitnagar	West Bengal	3.7
Mettupalayam	Coimbatore	2.0
Thirthahalli	Karnataka	2.0
Sree vardhan	Maharashtra	2.0

Soil: Deep, well-drained soil.

Temp- 14º C to 36º C, Altitude- 1000m MSL

Propagation: Seeds

Selection of mother palms- Early bearing, stabilized yield, regular bearing, high percentage of fruit set, 8-9 leaves/palm.

Selection of nuts: Above 35gm, should float vertically when immersed in water.

Primary nursery: Whole seed nuts are sown at 5 cm distance in vertical position with calyx and just covered. Germinates in 50-100 days.

Secondary nursery: After 6 months in primary nursery planted at 30cm spacing. Nursery should be under shade.

Seedlings of one to one and half years old are transplanted in the main field. Seedlings with more than five leaves, four nodes, and 20cm height are selected. Planted in 90X90X90cm pits during May- June.

Spacing: 2.7X 2.7m

Fertilizers: NPK 100: 40: 140kg/ha

2 splits May- June (1/3) Sep-Oct (2/3rd).

Intercrops: Banana, Betel vine, Tapioca, Pepper, Pineapple, Coconut, Jack fruit.

Mixed crop: Pepper, Cocoa, Banana, Lime, Betel vine.

Harvest: The climber climbs at one palm, harvest and then pulls the nearest palm with a hook and swing to it to harvest the nut. One climber may harvest 100 palms by practice. The harvested branches are lowered to the ground using a rope.

Yield of ripe nuts- 700 to 1800kg/ha (Average)

Improved varieties- 20000 to 24000 kg/ha (ripe nuts) 2800 to 6000 kg/ha (chali)

Processing:

Neetadakka- Method of keeping the nuts fresh conditions by steeping in water. Fresh fruits are washed with 100ppm chlorine water and blanched in 0.2% $Cacl_2$ solution. Kept immersed in a solution of 0.1% sodium benzoate and 0.2% Potassium Meta bisulphite. In this method, fruits can be stored fresh for one year.

Kotapak or Chali: Only ripe fruits are harvested. Sundried for 40-45 days. Chali recovery 25%.

Grades of Chali: Moti, Srivardhan, Jamnagar, Jini.

Tender nuts: Harvesting green fruits at 6 months maturity. After dehusking, soft nuts are cut into pieces, boiled with dilute extract of previous boiling and drying. The same water is reused for 3 to 4batches. The extract is concentrated to make **"Thick kali"** .

Types (Based on cuts and shapes)

Api or Unde - Processed without cutting

Batlu- Cut transversly into two halves

Choor- Several longitudinal cuttings

Podi- Nuts are cut both longitudinally and transversly 3-4 times.

Scented supari:

Prepared from chali and kalipak. Cut into bits and scented with essence of spices, synthetic flavor, menthol etc.,

Pest and disease: Fruit rot, foot rot (Anabe), inflorescence die back and leaf disease.

Fruit rot (Koleroga/ Mahali)

10-90% loss is reported, water soaked lesion on nuts become dark green. Fungus spreads over the surface. Appears 15 days after monsoon, high RH and low temp with bright sunshine favors the disease. Controlled by spraying Bordeaux mixture and polythene covering of bunches.

Bud rot:

Yellowing of spindle leaf, rotting of growing bud and surrounding tissues. Scoop out infected tissues and apply Bordeaux paste, then cover with polythene sheet.

Foot rot or Anabe:

Called Betelnut plague. 5-25% loss. Yellowing of outer whorl of leaves which gradually extends to the inner whorls. Development of inflorescence is arrested and nuts shed. Dull brownish patch occurs at the base of the palm and exudates ooze out. Caused by *Ganoderma lucidum* (fungus). Isolate affected palms by deep trenches around the affected palms. Root feeding of 1.5% Calixin solution (125ml).

Nut splitting- Boron deficiency spraying Borax 2g/lit.

Mites: Colonise the lower surface of the leaves which dry. Spray dicofol- 1.5%

Soil and climate

- Arecanut is capable of growing in a variety of soils.
- It thrives best in well drained soils.

- Adequate protection from exposure to South-Western sun is essential to avoid sun-scorch.
- Quickgrowing shade trees have to be planted on the southern and western sides well in advance of planting seedlings.
- It is sensitive to moisture deficit and should be grown where adequate water facilities are available.
- Grows in a wide range of temperature ranging from minimum of 40C to a maximum of 400C.
- Altitude upto 1000 m above Msl. Rainfall – 750 – 4500 mm.

Season

June – December is found to be the optimum.

Sowing

For raising seedlings seed nuts from pre-marked and pre-potent mother palms of outstanding performance are selected and sown at a spacing of 5 - 6 cm apart in sand beds under partial shade with their stalk end pointing upwards. After the sprouts have produced two to three leaves, they are transplanted to a polythene bag 30 x 10 cm filled with forest soil and are allowed to grow for 12 to 18 months under partial shade. The seedlings can also be transplanted in secondary nursery beds with a spacing of 30 cm on either side. Periodical watering should be given.

Planting

Dwarf and compact seedlings with more number of leaves should be selected. Seedlings of 1 - 2 years age are planted in pits of about 90 cm x 90 cm x 90 cm at a spacing of 2.75 m either way and covered with soil to the collar level and pressed around. Provide shade during summer months. Growing Banana or other crops in advance may also provide shade.

Irrigation

Irrigate weekly once during November – February, once in 4 days during March – May. Flood irrigation 175 lit/ tree/ day. In drip irrigation 16 – 20 lit/ tree/ day.

Manuring

Apply to each bearing palm (5 years and above) 10 - 15 kg of FYM or green leaf. 100:40:140 g of NPK/ tree/ year. To palms less than five years old, half of the above dose is recommended. Manures are applied during January - February after the North - East monsoon in a basin of 0.75-1.00 m radius around the tree to a depth of 20 - 30 cm.

After cultivation

Weeding is done twice or thrice a year by spade digging. Wherever the land is sloppy, terracing has to be done to prevent soil erosion.

Intercropping Cocoa, black pepper, coffee, vanilla, cinnamon, clove and citrus
Plant protection

Pests

Mites
Mites can be controlled by spraying Dicofol 18.5 EC at 2.5 ml/lit.

Spindle bug
Drenching spray with Methyl parathion 1.3 D @ 2.5 g/lit of water or Dimethoate @ 1.5 ml/lit.

Inflorescence caterpillars
Dust Methyl parathion 20 EC 2 ml/lit or WP @ 2.5 g in one litre of water.

Nematode:
Soil application of *P. fluorescens* (Pfbv 22) and B. subtilis (Bbv 57) each @ g / vine was found to be effective in reducing the root knot and reniform nematode population in black pepper.

Diseases

Bud rot or Mahali disease
Infected tissues of the bud should be scooped off and treated with 10 % Bordeaux paste. Destruction and removal of seed palms and also bunches affected by Mahali and drenching crowns of surrounding healthy palms with 1 % Bordeaux mixture would help in minimizing the incidence of the disease.

Foot rot or Anabe
Affected palms have to be isolated by digging trenches all round. The severely affected palms should be cut and destroyed. The stumps should be pulled out by digging and the drainage improved. Soil application of neem cake @ 2 kg / palm / year followed by root feeding with 125 ml of 1.5 % (15 ml/litre of water) Tridemorph at 3 months interval or Soil drenching of Bordeaux mixture (1%).

Stem breaking wrap up of the green portion of the stem which is exposed to the South-West sun to protect against sun-scorch.

Yellow Leaf Disease

- Application of balanced nutrients with additional quantity of super phosphate
- Apply 1 kg of lime/tree/year
- Apply organic manures @ 12 kg/ tree/year.

Leaf spot

Foliar spray with Bordeaux mixture 1 % or 0.2 % Dithane M 45

Nut crack

Spray Borax 2 g/lit with proper water management

Harvest

The bearing starts after 5 years of planting. Nuts are harvested when they are three quarters ripe. The number of harvests will vary from three to five in one year depending upon the season and place of cultivation.

Yield

An average of about 1250 kg/ha can be obtained.

Cashew (*Anacardium occidentale*)

Native of Brazil

Introduced in India during 16th Century for the purpose of afforestation and soil conservation.

India is the largest producer, processor, consumer and exporter of cashew in the world.

Commercial cultivation of cashew : in eight states of our country mainly in west and eastern coast viz., Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal.

India accounts for about 65 per cent of global cashew exports.

India exports cashew kernels to over 60 countries

US is the largest market for Indian cashew kernels

Rank	State Name	Area	Production	Yield
1	Maharashtra	184.0	225.0	1221.0
2	Andhra Pradesh	184.0	118.0	641.0

3	Odisha	164.0	101.0	616.0
4	Kerala	85.0	77.0	906.0
5	Karnataka	122.0	75.0	611.0
6	Tamil Nadu	136.0	62.0	454.0
7	Others	36.0	49.0	1357.0
8	Goa	57.0	30.0	526.0
9	West Bengal	11.0	12.0	1091.0
10	Jharkhand	12.0	5.0	417.0

USES:

The edible kernel is the highly-prized cashew nut of commerce, which is usually sold as roasted cashews. Small or broken nuts may be used in confectionery or made into cashew butter, which is similar to peanut butter.. The commercially valuable cashew nut shell liquid (C.N.S.L.) is extracted from the shell., C.N.S.L. is used in insulating varnishes, lacquers, inks, brake linings, and in acid- and alkali-resistant cement and tiles. The testa surrounding the kernel contains 25% tannin.

The apple is edible but often astringent. It may be used in jam, jelly, syrup or fermented for wine.

MAJOR CASHEW GROWING DISTRICTS IN TAMIL NADU

Cuddalore, Pudukottai, Ariyalur, Sivagangai and Theni Varieties:

Kerala Varieties	Akshaya,Amrutha Anagha),Anakkayam-1, Dhana,Dharasree K-22-1,Kanaka ,Madakkathara 1,Madakkathara-2 ,Priyanka ,Sulabha
Tamil nadu varieties	V RI 1, VRI 2, VRI 3, VRI4, VRI(CW) H1
Andra Pradesh	BPP-1,BPP-2,BPP-3,BPP-4,BPP-5,BPP-6,BPP-8

Karnataka	Chintamani-1,NRCC-1,NRCC-2,Ullal-1,Ullal-
	2,Ullal-3,Ullal-4,UN-50
Maharashtra	Vengurla-1,Vengurla-2,Vengurla-3,Vengurla4,Vengurla-5,Vengurla-6,Vengurla-7, Vengurla-7
Goa	Goa-1
Orissa	Bhubaneswar-1
West Bengal	Jhargram-1

Important Varieties and their special characters

Priyanka (Hybrid)	Kernel weight : 2.87 g, Shelling% : 26.57, Export grade : W180 Mean nut yield/tree : 17.03 Kg
Madakkathara 2	Nut weight : 7.25 g, Kernel weight : 1.88 g, Shelling% : 26 Export grade : W210, Mean nut yield/tree : 17 Kg
Vengurla 4 (Hybrid)	Nut weight : 7.7 g, Kernel weight : 1.91 g, Shelling% : 31 Export grade : W210, Mean nut yield/tree : 17.2 Kg
Vengurla 7 (Hybrid)	Nut weight : 10 g, Kernel weight : 2.9 g, Shelling% : 30.5 Export grade : W180, Mean nut yield/tree : 18.5 Kg
BPP 8 (Hybrid)	Nut weight : 8.2 g, Kernel weight : 1.89 g, Shelling% : 29 Export grade : W210, Mean nut yield/tree : 14.5 Kg
VRI 3	Compact canopy, Early flowering, Bold nuts 7.2 g, Kernel 2.05g Shelling 29.1%, Kernel count W 210, Easy peeling testa , Yield: 2700 kg/ha
VRI(Cw) H1	Cluster bearing, Bold nuts 7.2 g, Kernel 2.2 g, Shelling 30.5 % Kernel count W 210, Easy peeling testa , Compact canopy Yield: 2900 kg/ha
Ullal 2	Nut weight : 7.2 g, Kernel weight : 2.15 g, Shelling% : 31 Export grade : W210, Mean nut yield/tree : 9.5 Kg

NRCC 2	Nut weight : 9.2 g, Kernel weight : 2.15 g, Shelling% : 28.6 Export grade : W210, Mean nut yield/tree : 9 Kg

Soil and climate

Cashew is essentially a tropical crop, grows best in the warm, moist and typically tropical climate.

The distribution of cashew is restricted to altitudes below 700 m where the temperature does not fall below 20˚C for prolonged periods, although it may be found growing at elevation up to 1200 m. It is best adopted to the coastal regions. The cashew is hardy and drought resistant, but it is damaged by frost.

Cashew is an hardy crop.

It can be grown on a wide range of soils except heavy clay, water logged and saline soils.

Well drained red, sandy and laterite soils are ideal for good growth and yield of cashew.

Propagation in cashew

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

Production of scion sticks

The Scion Bank should be established with the recommended varieties of the region.

The plants should be panted in a closer spacing of 4mx4m

The plants in the scion bank should be maintained by heading back the top to a height of 1.5 m from ground level and by pruning the dried branches.

Pruning of trees may be carried out annually during September –October in the scion bank.

Variety of scion and precuring

Choose non-flowered, 3-5 month old lateral shoots of current season's growth.

The chosen shoots should be about 10-12 cm long, straight, brown coloured having dormant plumpy terminal buds.

The top 4-5 leaves should be dark green in colour indicating proper maturity of the scion sticks.The chosen scion sticks should be precured by clipping off leaf blades, leaving petiole.

The scion sticks can be detached from the mother tree after 8-10 days, before they sprout and utilized for grafting.

Collection of scion stick

The precured scion sticks should be separated early in the morning to avoid desiccation and its length should not less than 10cm.

Soon after separation from the mother tree, scion sticks should be dipped in water and placed in a polythene bag of 100 guage thickness and brought to the nursery shed for grafting.

The scion sticks wrapped in sphagnum moss cloth and placed in a polythene bag of 100 guage can be kept for 3-4 days and used for grafting, if necessary.

Raising of root stock seedlings:

Selection of seednuts

Collect fresh seednuts during the peak period of harvest in February-April and sun dried for 2-3 days.

Medium sized nuts of 6-7 gm should be chosen.

Prepare the potting mixture in the proportion of one part red soil, one part sand and one part compost

Use high density polythene bags of 25 cm x 15 cm size and 300 gauge thickness for filling potting mixture.

The seednuts should be soaked in water for 12-24 hours before sowing in order to get good germination.

Sow the seeds in the centre of the bag, stalk-end upwards, with a depth of not more than 2.5 cm

The seednuts usually germinate within 15-20 days after sowing.

Maintenance of seedlings in the nursery

Daily watering is required during summer season.

The side shoots arising from the leaf axils should be removed frequently.

Choose 45-60 days old seedlings as root stocks for grafting.

Soft wood grafting technique: Preparation of root stock

Remove the leaves by a sharp grafting knife leaving two pairs bottom leaves.

At a height of 15-20 cm from ground level a transverse cut is made on the root stock and the terminal shoot is removed.

A cleft of 6-7 cm deep is made in the middle of the decapitated stem by giving a longitudinal cut.

A little portion of wood is removed from the inner sides of the cleft at the top, so that after grafting the joint will be perfect.

Preparation of scion

Choose a matching scion stick of the same thickness as that of the root stock of 10-12cm long by cutting off the excess portion at the bottom.

Shape the cut end of the scion in to a wedge of 6-7 cm long by chopping off the bark and little portion of wood from two opposite sides.

Grafting

The wedge of the scion is put into the cleft of the root stock to see that the cambial layers of both the root stock and the scion come in perfect contact with each other.

The graft joint is secured firmly with 2.5cm wide and 30cm long polythene strip of 100 gauge thickness

A long and narrow HD polythene bag of 15cm x 12.5cm size and 100 gauge thickness is added on the grafted plant, tied at the bottom with a single knot in order to protect the scion stick from drying up.

The freshly grafted plants are left in the nursery shed for about two weeks to encourage sprouting of the terminal buds.

After two weeks the polythene caps are removed gently and the grafts are shifted to open condition in the nursery.

Within 3-4 weeks, 70-80% of the grafts will sprout.

Spacing: 7 m either way

200 plants/ha can be planted.

Preparation of field

Pits of 45 cm x 45 cm x 45 cm size are dug and filled up with a mixture of soil + 10 kg FYM + one kg neem cake

High Density Planting

Spacing of 5 x 4 m accommodating 500 plants per hectare is recommended prune the interlocking branches during the July-August to maintain the frame

Manuring :

Manures and fertilizers	**I year old**	**I I year old**	**III year old**	**I V year old**	**V year onwards**
FYM or compost (kg)	10	20	20	30	50
N (g)	70	140	210	280	500
P (g)	40	80	120	160	200
K (g)	60	120	180	240	300

Fertilizer application: during November - December in the East Coast areas. Wherever possible the fertilizer can be applied in 2 equal split doses during June-July and October-November

Intercropping

Plough the interspaces after the receipt of rain and raise either groundnut or pulses or minor millets till the trees reach bearing age

Irrigation: Normally grown as a rainfed crop. Irrigation once in a month from flowering to fruit maturity stage is good to increase the yield.

Training and pruning develop the trunk to a height of 1 m by removing low lying branches. The dried twigs and branches should be removed every year

Rejuvenation of old cashew orchard by top working

Old and senile cashew orchards with poor yielder are cut down leaving a stump of 1 – 3 m height from the ground level.

The emerging new sprouts are used as rootstock for epicotyl grafting.

Suitable scions are collected and grafted on to the new sprouts.

Advantages of top working

Vigorous growth: Top worked trees are vigorous in growth, because of wellestablished root system.

Top worked trees starts yielding from second year itself after rejuvenation. Cost involved for top working could be recovered from the sale of wood in the first year itself.

Higher nut production could be seen beyond fifth year of the top worked trees,

We can have different varieties of cashew on a single tree

Harvest

The plant starts yielding 3rd year onwards. The peak picking months are March and May. Good nuts are grey green, smooth and well filled. After picking, the nuts are separated from the apple and dried in the sun for two to three days to bring down the moisture content to 10 to 12 %. Properly dried nuts are packed in alkathene bags. This will keep for 6 months.

Yield

About 3 - 4 kg/tree/year can be obtained

The nuts which are required to be processed at factory should be dried for 1-2 days to reduce and maintain the moisture level of 7 - 8 percent.

The processing of raw nuts involves

Roasting, shelling, drying, peeling, grading and packing

PROCESSING OF CASHEWNUT

Drum roasting

This is one of the oldest and more widely used methods. The nuts are fed into a rotating red hot drum which will ignite the shell maintaining its temperature because of the burning of the shell liquid. The drum is kept in rotation for 3-4 minutes and the roasted nuts are discharged from the lower end of the drum and immediately covered by ash after sprayed with little water, so as to absorb the oil on the surface. This facilitates the removal of the remaining oil on the shell. Due to draw backs of the method is superseded by oil bath roasting.

Steam roasting

The raw nuts are steam cooked at about 120-140 lbs/sq inch pressure. Shell oil can be extracted in later stages by crushing. The nuts are shelled by hand and leg operated shelling machines.

Oil bath roasting

In this method conditioned nuts are passed through CNSL bath heated to 1702000C by conveyer buckets for 1-2 minutes during which period the shell gets heated rupturing the wall and releasing the oil into the bath. The oil is recovered by continuous over flow arrangement. The roasted nuts are centrifuged to remove adhering oil, cooled and shelled by hand and leg operated shelling machines. The kernel with the adhering testa is scooped out using a sharp needle

Steam roasting

Steam roasting is the commonly used method by most of the processing units. In the case of steam roasting, the raw nuts are steam roasted at about 100-lb pressure for about 25-30 minutes. Then the nuts are allowed to cool for 24 hours and taken for shelling **Shelling :**

Cashew nuts after roasting and cooling are to be shelled to remove kernels. Hands are to be protected from Cashew Nut Shell Liquid (CNSL) which is highly corrosive. Hand gloves should be used while shelling. For the same reason, it is advisable to dust the nuts with wood ash. Commercial processing units use foot operated shell cutters (mechanical device) for shelling. This

device consists of a pair of blade (knives) shaped in the counter of half a nut which could be operated by foot. The blades cut through the shell all around the nut, leaving the kernel untouched.

Drying: The kernels after shelling will have moisture content of more than 6 per cent.

Drying of these kernels is necessary to prevent fungus attack during subsequent storage and to facilitate peeling of testa.

The kernels are to be dried to moisture content of about 4 - 5 per cent. This is done by drying the kernels in hot chambers at 70 - 80 C in perforated trays for about 6 - 8 hours.

Uniform drying could be achieved with a cross flow drier using forced hot air circulation through the kernel layers.

Peeling: This process involves the removal of testa (seed coat) from the kernel. Peeling is done using a sharp knife or bamboo piece.

Grading

Kernels are graded according to the size manually.

In the International Market bold whole kernels fetch premium price. The grading standards developed in India refer to white whole (undamaged) kernels and indicate the number of kernels per lb of weight.

The largest kernels come in the grade W 210 (440-460/kg) and the smallest of the seven grades is W 500 (1000-1100/kg).

Other grades include Scorched wholes, Scorched butts, Large white pieces, Small white pieces, Baby bitsetc.,

Packaging

As far as possible packaging material used should be eco-friendly and recyclable and containers are hermetically sealed after filling carbon dioxide.

Composition of kernels:

Moisture	**5.9**	Total Fat	64
Total Minerals	2.4	Saturated	12.9

Total Fiber	1.3	Unsaturated (Oleic)	36.8
Energy	785	Unsaturated (Linoleic)	10.2
Protein	24	Carbohydrate	41

COCOA Theobroma cacao Malvaceae

Cocoa is an important commercial plantation crop of the world. Cocoa is a crop of humid tropics and so it was introduced as a mixed crop in India in areas where the environments suit the crop. It is cultivated in coconut and arecanut plantations large scale from 1970 onwards. It is grown as an under- storey intercrop with sufficient shade in southern states of India

Origin and distribution

Native: Amazon valley of South America. Now cultivated largely in Ghana, Nigeria, Sierra leon,Cameroon,Brazil, Equador, West indies and Malaysia. In India Cocoa is cultivated in Kerala, Karnataka, Tamil Nadu

Percentage nutritive value of cocoa and chocolate

Constituents	Cocoa	Chocolate
Water	4.6	5.9
Protein	21.6	12.9
Fat	28.6	48.7
Carbohydrate	37.7	30.0

There are two major varietal types in cocoa

Criollo and Forastero

Forastero types are known to perform well under Indian conditions.

M16.9, M13.12, G15.9, GII 19.5, G IV 16.5, G VI.55 and G VI 56 are the some selections recommended for cultivation. CPCRI, Kasaragod recommends some selections introduced from Malaya – I-21, II-11, II-18, II-67, III-5 and III-101 for commercial cultivations.

Character	**Criollo**	**Forestero**
Cotyledons	Plumpy and white when fresh Turn cinnamon colour on fermentation	Flat and purple when fresh turn dark chocolate brown on fermentation
Pod colour	Dark Red	Yellow
Other pod characters	Rough surface, Ridges prominent, pronounced point and thin walled.	Smooth, inconspicous ridges, thick walled, melon shaped with roundfed end
Flavour and aroma	Bland flavour	Harsh flavour, bitter taste
Duration of fermentation	3 days	6 days
Adaptability in India	Poor adaptability and less yield potential and hence discouraged for commercial cultivation	Good adaptability and high yielding and hence recommended for commercial cultivation

Climate and soil
Nursery Practices
Establishing plantation
Manuring
Irrigation
Training and Pruning
Harvesting
Processing

Refer Practical manual

COFFEE

Botanical name: *Coffea sp*.

Family: Rubiaceae

- One of the most agricultural export products.
- Second most important after petroleum products in the international trade.
- Exports and imports of coffee are controlled by **International Coffee Organisation.**
- Plays a major role in the economy of many countries.
- According to **Coffee Act**, Coffee grown anywhere in India is the property of coffee board and thus the export and international trade of coffee is controlled by **Coffee board.**

Origin: Ethiopia and Africa.

Distribution: Even before 1200A.D it was consumed in Aden & Mecca. Commercial cultivation started in 1729. Since then Brazil is the major supplier (2/3rd) of coffee to the world. Coffee was introduced in 1670 India by a pilgrim, Baba Budan who brought 7 seeds from Yemen and raised near Chickmangalum (Kar).

World: 10.55m ha, 7.7 mill.T

India: 3.2 lakh ha, 2.7mill.T

World- Brazil(2/3), Abyssinia, Columbia, Guatemala, S.India etc.

India: Karnataka (52% area), Kerala (28%), AP, Tamil Nadu

Species and cultivars (50-60 in the genus)

Four/ Five species contribute to commercial coffee

- *Coffea arabica* (2n=44) Tetraploid, superior, high altutudes.
- *Coffea robusta* (2n=22) Diploid, Inferior, Low altitude.
- *Coffea liberica* (Tree coffee):

12-15cm height, fruits 2.5cm dia. Thrives in lower altitudes Berries do not drop after ripening. Widely used for hybridization and a root stock for grafting C.arabica. generally planted in the borders of estate.

Distinguishing features:

	C.arabica	***C.robusta***
Elevation	1000-1500m	500-1000m
Temperature	15-25^{o}C, cool	20-30^{o}C-hot , humid
RH	70-80%	80-90%
Annual Rainfall	1600-2500mm	1000-2000mm
Blossom showers	Mar-Apr	Feb-Mar
Backing showers	Apr-May	Mar-Apr
Shade	Medium-light	Light shade
Fruit maturity	8-9 months	10-11 months

Yield	2500-3000kg/ha	1250-1750kg/ha
Pollination	Self	Cross

Selection and hybridization been done by CCRI-Central Research Institute, Chikmaglur.

Varieties:

C.arabica : Sel -1, 3, 5, 6 (C.arabica X C.robusta), 7(San Raman Hybrids), 8, 9, 10.

C.robusta : Sel-IR, Sel -2R, Sel -3R, BR9, BR10, BR 11

Sel.3 (S.795) - Good 70% 'A' grade beans

Low % of defective beans

Yield 2000kg/ha.

Sel.7 (San Raman hybrid)

San Raman is a dwarf mutant of Arabica.

San Raman X S.795 ➐7.1

S.7.2 X HDT (Hibrido –da Timor)

↓

5.7.3 - suitable for close planting.

Yield 1500kg/ha, drought tolerant.

Sel.8 (HDT)

Natural hybrid of R X A spotted in Timer Island, yield (800-1200kg) cup quality similar to Arabica. Highest resistance to leaf rust.

Sel.9:

HDT X Tafarikela (Arabica)

↓

Sel.9 -1700kg/ha. 65% A grade beans. Drought hardy, widely adoptable.

Sel.12: Cauvery/ Catimor

Caturra X HDT semi- dwarf hybrid.

Compact bushes, suits HDP, 3000kg (potential yield), Maximum record 6000kg/ha. 64% 'A' grade. Very popular, 2000ha.

Popular Arabica selection: Sln 3, 5, 6, 8 , 9, Cauvery.

Karnataka: Chickmaglur, Mudigere, S.coorg.

TN - Pulneys (S.5, 6, 9), shervroys (S. 795, S.9).

Botany:

Perennial, evergreen. It has a prominent vertical growth from which sub lateral shoots develop. The vegetative growth of a year determines cropping in the next year. Therefore crop regulation should be done by pruning. Root system is shallow.

It is a short day plant. Floral initiation occurs during Sep- Dec. Flower buds are produced in the axils. Inflorescence is cymose. 4-5 inflorescence each with 1-4 flowers are found per axil (Arabica). Robusta has 5-6 inflorescence/ axil.

Flower buds grow to a length of 7-8mm and remain quiescent until it is stimulated by blossom showers. Adverse weather high temperature leads to Star-flower- They are small, fleshy and green. Rain before and after flower opening affects pollination. Wind, gravity, bees are pollination agents.

Duration of flower to develop into fruit is 6-8 months in Arabica and 9-11 months in robusta. Fruit is a 'drupe' and contains two seeds. Sometimes abortion of one ovule leads to formation of single seeded fruit called 'pea berry' seed coat is a silver skin.

Bean defects:

1. Pea berry- single seeded
2. 3 or more seeds formed in a single fruit- Triangular seeds. Elephant beans – hollow and bit / defective.
3. Endosperm shows partial development – Floats/ Jollu **Nursery:**

Propagation through seeds. Seeds have no dormancy. Seeds are sown in raised nursery beds in rows at 3cm apart. Season Dec-Jan. they germinate in 45 days. At button/ topee stage, they are transplanted to secondary nursery/ poly bags after nipping off tap root.

Location:

North/ Eastern slope is preferred. Southern/ Eastern slopes suffer from longer exposure to sun. eastern winds may damage the crop during Dec-Feb. wind breaks with tall trees viz. silver oak, orange/ tree coffee should be provided. In sloppy lands to conserve top soil, countour bunds should be formed. Low canopy trees viz. dadap, silver oak should be planted.

Spacing:

Arabica – Talls- 6' X 6', 7' X 7', 7' X 6'

Dwarf – 5' X 5'

Robusta – 10' X 10' / 12' X 12'

C X R – 8' X 8', 9' X 9' **Planting:**

- Pitz- 45cm3 during Mar-Apr

- 6-8 months old seedlings are planted during Aug- Sep
- 16-18 months old (secondary nursery) seedlings are planting during June.

Shade trees: Shade belts in E.W. direction at 20' spacing X 40' bet rows. Permanent shade trees- 30-40' distance.

Grevellia robusta (Silver oak), *Erythrina lithosperma, Ficus sp., Citrus sp.* Robusta is planted at wider spacing of 10-12' comes to yield only after 6-7 years. Inter planting can be done with var. Cauvery which bears in 3 years at 5' spacing. Additionally 3230 plants can be in corporate and later removed after spread of robusta.

Training:

Gives frame work and proper shape to the plant.

1. single stem
2. Multiple stem are followed.

Single stem: High of the bush is restricted to a convenient length by topping. Topping is removing the vertically growing main stem two inches above the nodes at a particular height.

Arabica tall- 2.5 ft

Dwarf- 3-4.5 ft.

First topping Arabica (9-12 months), Robusta (18-24months), second tire in Arabica is topped at 4.5- 5 ft(Arabica).

Multiple stem: It is easy and cheaper.

Practiced in Africa/ Latin America. Once main stems are exhausted, new multiple stems are encouraged by stumping / bending. In India, multiple stem system is followed in replanted fields and HDP.

Pruning:

To regulate cropping wood. Removal of old, unproductive, crisscross branches, diseased damaged branches etc. Remove new flush near 15cm around main stem during June-July and Aug-Sep.

Rejuvenation:

Collar pruned/ stumped at 30cm above ground level after the receipt of summer showers in Mar- Apr. Cut surface should be treated with Bordeaux paste (1kg CuSo4 + 1kg lime + 4.5 lit of water.)

Harvesting:

Coffea Arabica- Comes to bearing in 3-4 years. Full production after 6-8 years. Harvesting period is 4 months for Arabica and 5 months for robusta from Nov-Feb.

Types of picking:

i) Fly picking- First, fully ripened fruits are picked. ii) Main picking- 3-5 pickings at 10-15 days interval.

iii) Stripping- last, all ripened and unripe fruits are stripped out.

in Brazil, mechanical harvest is also practiced.

Yield: Arabica- 2500 to 3000 kg/ha. Robusta- 1250 to 1750 kg/ha
Indian average is **946 kg/ha**. **Brazil- >3000 kg/ha.**

Wet processing is done for arabica and results in "Mild coffee". Dry processing is generally used for robusta and in Brazil 90% in arabica also.

Natural (Sun) –for 3-4 weaks upto 12% moisture

Drying

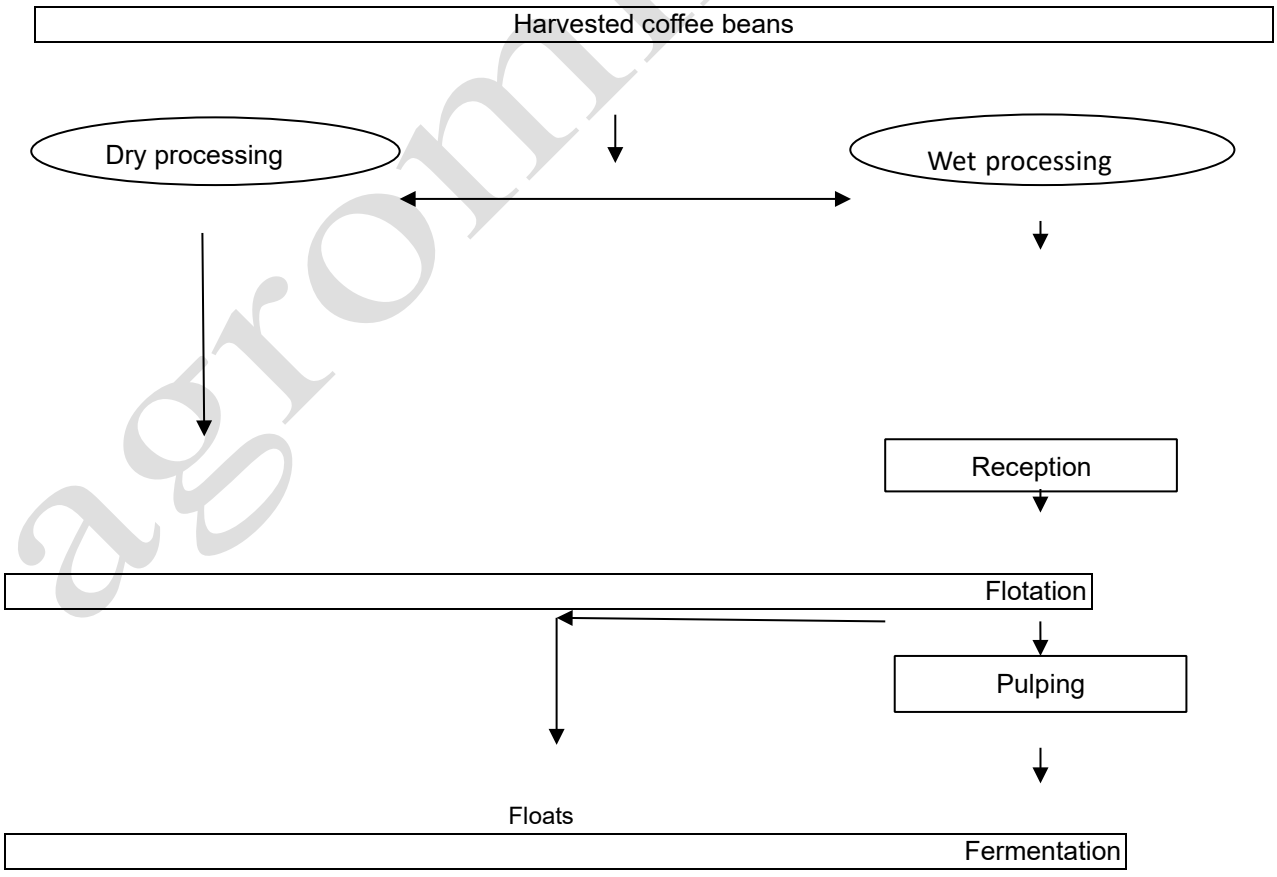
Artificial- below 60° C (Driers – Static, rotary, horizontal, vertical models)

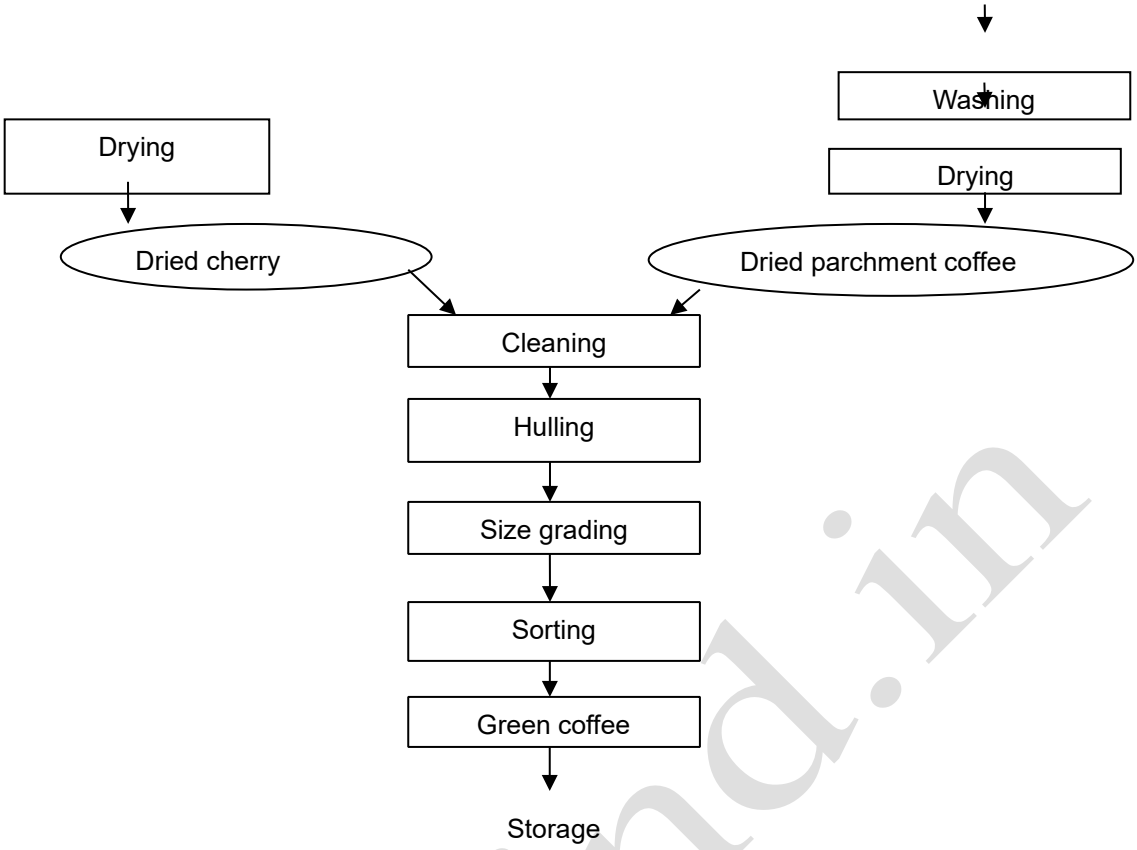
Wet processing:

1. **Receiving**- Separate and remove floats, sand, stones, leaves, twigs etc.,
2. **Pulpling**- Removal of outer skin and pulp along with running water.Pulpers: Disc pulper, Drum pulper, roller pulper along etc.,
3. **Fermentation**- To hydrolyse mucilage and remove during washing. Some unwanted polyphenols will get dissolved and removed. Enzymes or alkaline solution is also added for repid removal of mucilage.
4. **Washing-** To remove mucilage. Horizantal washer, vertical washer are available.
5. **Drying-** Sun drying to get the find moisture content of 11%.
6. **Curing-** Hulling (Peeling) - Polishing- Grading- Sorting- Storage.

Processing:

Various stages of dry and wet processing





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from Yemen and raised near Chickmangalum (Kar). World- Brazil(2/3), Abyssinia, Columbia, Guatemala, S.India etc.

Major Coffee Producing Countries

• South America:- brazil, Columbia, Venezuela

• Africa:- Kenya, Ethiopia etc.

• Central America:- costa rica, Jamaica, Mexico etc.

• Asia:- India, Indonesia.

India: Karnataka (55% area), Kerala (28%), AP, Tamil Nadu

India is the seventh largest coffee producer and the third largest in Asia

Karnataka accounts for 70 per cent production of coffee in the country

Coffee is grown in three regions of India with Karnataka, Kerala and Tamil Nadu forming the traditional coffee growing region of South India, followed by the new areas developed in the non-traditional areas of Andhra

Pradesh and Orissa in the eastern coast of the country and with a third region comprising the states of Assam, Manipur, Meghalaya, Mizoram, Tripura, Nagaland and Arunachal Pradesh of North eastern India, popularly known as "Seven Sister States of India

Coffee production in India: (In tonnes) -2014-15

Arabica – 105500, Robusta - 239250, Total - 344750

Uses of Coffee:

1. Used as beverage and helps the people suffering from malformation.

2. Taking coffee half to one cup per day over comes Kwashiorkar disease caused by protein deficiency in 20 days.

3. Counter affects the skin disease 'Pellagra" which is caused by deficiency of vitamin 'Niacin.'

Species and cultivars (50-60 in the genus)

- Four/ Five species contribute to commercial coffee • *Coffea arabica* (2n=44) Tetraploid, superior, high altutudes.

- *Coffea robusta* (2n=22) Diploid, Inferior, Low altitude.
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Backing showers	Apr-May	Mar-Apr
Shade	Medium-light	Light shade
Fruit maturity	8-9 months	10-11 months
Yield	2500-3000kg/ha	1250-1750kg/ha
Pollination	Self	Cross

Varieties

Arabica varieties : Sln 795, Sln 7, Sln 9, Sln 10, Cauvery and its selections and HRC (Hawaiian Red Caturra), Chandragiri and san Roman

Robusta varieties

Sln 274, Sln 270, Sln 3

Varieties	**Special characters**
Selection 1 (S288)	Resistance to leaf rust race 1 & 2, high yielding. Wider adaptability

Selection 3 (S795)	Resistance to leaf rust race 1 and 2, 700 -1200kg/ha Bold fruits 75% A grade
Selection 5	Small, oblong fruits 900 – 1100kg/ha
Selection 6	High A grade beans, 900 – 1000kg/ha
Selection 7	Dwarf in stature, segregates to tall by 30%
Selection 8	*Highest resistance to leaf rust, drooping branches*
Selection 9	***Drought hardy, suitable to different coffee zones***
Selection 10	Resistant to leaf rust
Selection 11	Field resistance to rust and drought hardiness
Cauvery	Plants are dwarf, suitable for high density planting Yield – 3000kg/ha More a grade beans with superior cup quality
Selection 12	*Precocious, suitable for close planting, resistant to leaf rust*

Soil and climate

Soil should be deep, friable, open textured rich in plant nutrients with plenty of humus and of slightly acidic nature (pH – 4.5 to 6.5)

Seeds and sowing: Coffee is propagated by seeds

Season: June - December

Preparation of seeds

Healthy and well developed fully ripe berries are harvested from specially identified plants for use as seed bearers.

After discarding the floats, the sound fruits are depulped, sieved and mixed with sieved wood ash and dried in shade.

Seeds are treated with Agrosan or any Organ mercurial compound to prevent fungal

The seed is then graded to remove all cut, triangular and elephant beans.

Nursery practices

Select light loamy soil of good drainage with high organic matter content with water and shade facilities.

Form raised beds of 15 cm height, 1m width and at convenient length. Incorporate 30 - 40 kg of well rotten compost, 2 kg of finely sieved agricultural lime and 400 g of rock phosphate to a bed of 1 x 6 m size.

Sowing

Pre-sowing seed treatment with *Azospirillum* and *Phosphobacteria* can be done.

Seeds are sown in December - January in the bed 1.5 - 2.5 cm apart with the flat side down wards in regular rows.

Then they are covered with a thin layer of fine soil and a layer of paddy straw.

Water the beds daily and protect from direct sunlight by an overhead pandal.

Seeds germinate in about 45 days after which they are transplanted to a secondary nursery beds for raising ball or Bag nursery.

Bag nursery

Polythene bags with adequate number of holes in the bottom half are taken and are filled with a prepared mixture containing jungle soil, FYM and sand in the proportion of 6:2:1.

An area of 12 x 8 m can accommodate 5000 seedlings.

Seedlings are planted in polythene bags

Preparation of field

Selective felling may be done while retaining a number of desirable shade trees.

Terracing should be done in deep sloppy areas.

After the summer showers, pits of 45 cm x 45 cm x 45 cm are dug at 1.25 - 2.5 m apart.

The pits are left open for weathering and then filled and heaped for planting.

At the time of filling, apply 500 g of rock phosphate per pit along with top soil.

Planting is done along the contour in slopy areas.

Spacing

Arabica Coffee: 1.5 to 2.0 m either way.

Dwarf varieties: Sanraman: 1 x 1 m.

Robusta coffee: 2.5 m either way.

Planting shade trees

Dadap is commonly used as a lower canopy shade.

Two metre long stakes are planted for every two plants of coffee.

Silver Oak and Dadaps are planted during June when rains of South-West monsoon commences.

During summer the stem of young Dadaps are painted with diluted lime or wrapped in agave leaves or polythene sheets in order to prevent them from sun scorch.

Regulate shade by cutting criss-cross branches during monsoon season.

Silver oak trees are planted for permanent shade

Irrigation

It is generally grown as a rainfed crop. But irrigation with sprinkler during March - April increases blossoming and results in higher yields.

Species	**Pre-Blossom March N:P2O5:K2O**	**Post blossom May N:P2O5:K2O**	**–Mid monsoon August N:P2O5:K2O**	**Post-monsoon October N:P2O5:K2O**	**Total**
Arabica					
Young coffee 1st year after planting	15:10:15	15:10:15	-	15:10:15	45:30:45
2nd and 3rd year	20:10:20	20:10:20	-	20:15:20	60:45:60
4th year	30:20:30	20:20:20	-	30:20:30	80:60:80

Bearing coffee 5 years and above for less than one tonne/ha crop	40:30:40	40:30:40	-	40:30:40	140:90:120
For one tonne / ha and above	40:30:40	40:30:40	40:30:40	40:30:40	160:120:160
Robusta					
	40:30:40	--	--	40:30:40	80:60:80
	40:30:40	40:30:40	--	40:30:40	120:90:120

Aftercultivation

Weeding and mulching should be done as and when necessary.

Digging is done to a depth of 30 cm towards the end of monsoon (October - November).

The weeds and vegetative debris are completely turned under and buried in the soil while the stumps are removed. This is known as the cover digging. In sloppy areas dig trenches on the contour 45 cm wide and 30 cm deep of any convenient length.

Prune water shoots and disease affected shoots.

Harvest

Harvest starts during November and harvesting extends up to February.

Coffee fruits should be harvested as and when they become ripe.

Coffee is just ripe when on gently squeezing the fruits the beans inside come out easily.

Unripe fruits should be scrupulously sorted out before using the fruits for pulping. They may be dried separately as cherry.

Fly picking: Small scale picking of ripe berries during October to February

Main picking: Well-formed and ripened berries are harvested during December. Bulks of the yields are obtained from this picking

Stripping: Picking of all the berries left irrespective of ripening. **Cleanings:** This is collection of fruits that have been dropped during harvesting.

Unripe fruits should be scrupulously sorted out before using the fruits for pulping. They may be dried separately as cherry.

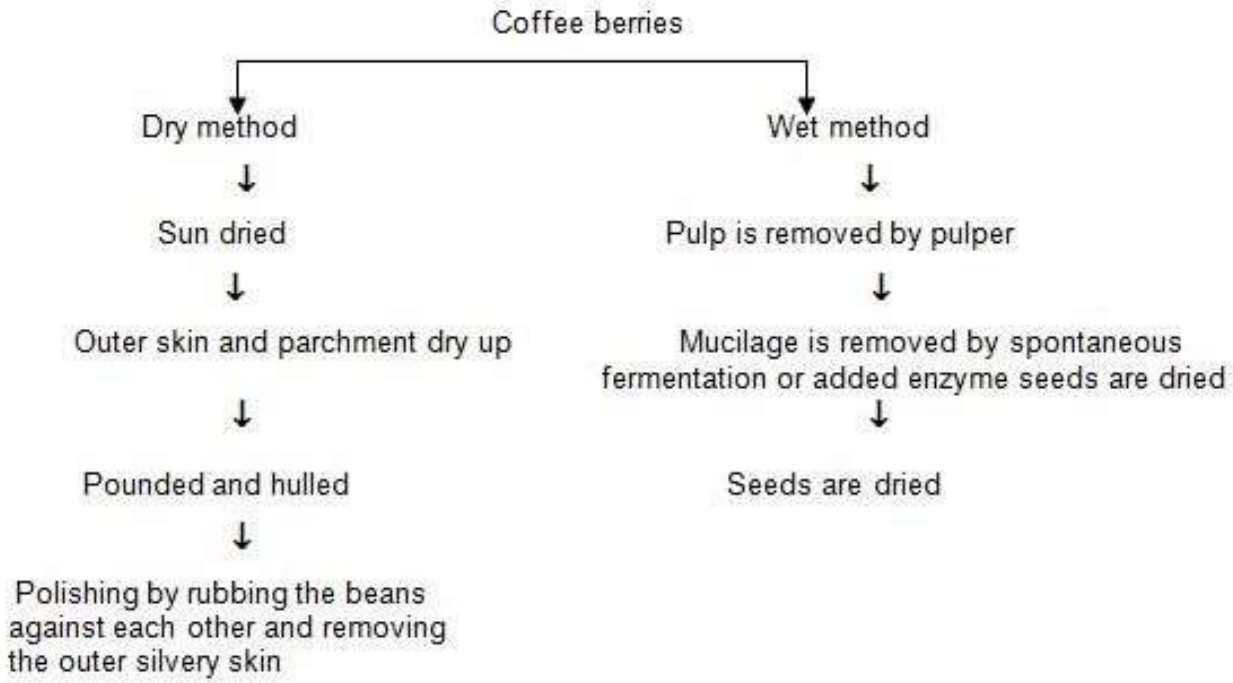
- **Yield**

  750 - 1000 kg dry parchment /ha **Processing procedure**

- Coffee processing consists of removing the skin, pulp, parchment and silver screen.
- The quality of the final product depends upon the manner of processing.
- It is the curing process that prepares the coffee beans for market.
- Two methods are employed for processing- the dry and wet.
- In the dry method the beans are sun dried.

In the wet method, known as the washed coffee process, pectin enzymes are used on selectively picked cherries to replace spontaneous fermentation.

Coffee curing process



Pulper cum Washer for Coffee

Function : To pulp and wash the coffee parchments

Pulping and washing are the two estate level important operations This unit consists of a puling unit and a washing unit. Compared to the traditional pulper and washers, which are operated separately with two different power units, this unit is operated by a single power source. Besides the water requirement for pulping and washing is reduced considerably.

Cost of the unit : Rs. 75,000

Cost of operation : Rs. 25/h

6. Salient features

- Suitable for both pulping and washing
- Requires less water (4 litres per kg of parchments) compared to 14 litres by the conventional pulper
- Breakage is minimum

Preparation of Parchment Coffee/Washed Coffee:

1) Pulping:

- After harvesting the desired type of fruits they should be pulped (removal of outer skin) on the same day so as to avoid fermentation commencing before pulping.
- As all the fruits may not be of uniform size,, they could be stored into different size and pulped separately.

2) Demucilaging and Washing:

- The mucilage on the parchment skin is. removed by
- (a) Natural fermentation
- (b) Treatment with alkali and • (c) Frictional removal in machine.

a) Natural Fermentation:

It is a critical stage in the processing. Fermentation should be wholly alcoholic.

The fermenting mass should not be allowed to dry up and may be turned over once or twice. It may be kept covered

The process of fermentation

Arabica - 36 to 48 hours, Robusta - 72 hours.

The beans feel rough and gritty when squeezed by hands similar to squeezing pebbles. Clean water is let in and washed by 3-4 changes of water.

Once used water should never be allowed to come in contact with parchment in the process of washing.

b) Treatment with Alkali

The pulped beans are drained of excess water and spread out in the vats uniformly and furrowed (wooden laddies. With long handle) 10% solution of caustic soda (sodium hydroxide) is evenly applied into furrows using a rose can. The parchment is agitated thoroughly by means of germanes. so as to make the alkali come into contact and trampled by feet for about half hour, When the parchment appears no longer slimy and makes a ratting noise, clean water is let

in and the parchment wasted pebbles clean with 3 Or 4 changes of water. Time for removal of mucilage by this method is half hour in case of *Arabicazmd. 1/2 to* 1hour *robusta*.

c) Removal of Mucilage by Friction.

There is pulp as Ranong and Agupulps in which pulping and demucilse me beans is done at some time.

2. Under Water Soaking:

Where water facilities are abundance percipient may be soaked under water for about 12 hours cover night then given a final wash. This method seems to improve the quality both in the appearance and cup of particularly coffee that are usually substandard.

3) Drying:

Drinage off as much as possible excess water facilities and shortens dry in time. Sun drying may taken 7 to 10 days under bright weather conditions. Drying is done when sample record the some weight for 2 days consecutively.

The dried beans are stored in gunny bags.

4) Before roosting of beans the Peeling i.e. outer coat is removed.

5) Grading according to different size is done. **B) Preparation of Cherry:**

Riped fruits after harvested should be spread evenly to a thickness of 8 em on clean drying ground or tiled or concrete floors. Coffee should be stirred and. ridged at least once every hour. About 12 to 15 days until bright weather conditions are required for complete drying. After drying cherry may be stored in gunny bag.

Cured coffee is graded according to sizes and shapes. The different plantation grades are:

- Pea berry (oval shaped beans)
- or A (first size in flats- bold, heavy and well formed)
- B (slightly smaller than O or A)
- C (slightly smaller than B)
- Triage (pale, discoloured, black spotted beans including bits)

TEA

Camellia sinensis

Family: Camelliaceae

Tea is derived from T'e (Amoy language) known in China in 2737 BC in 4th century used as medicine in China. Became a popular drink in England in 17th century. In India, tea was experimented in Calcutta in 1780. Large scale plantation was established in North India in 1834, first shipment to London in 1838. Tea was experimented in Nilgiris in 1832. UPASI – United Planters Association of South India, Coonoor was established in 1893. Some of the Tea plantations are at Nilgiris (Tamil Nadu), Anamalais (Coimbatore District), Central Travancore (Idukki, Kerala), Kannan Devan Hills (Idukki, Kerala), Wayanad (Kerala), Chickmagalur (Karnataka).

Tea is a labour intensive crop. With the liberalization of economy, tea industry is facing crisis as the import of tea from Sri Lanka has slashed out the price of Indian tea. In addition to concentration on export and domestic market, there is a need for product diversification like organic tea, green tea, flavoured tea and iced tea.

Introduction

Origin – China / South East Asia,

Distribution: India, China, Sri Lanka and Indonesia.

Area FIRST - China (10.09 lakh ha) II- India (5.78 lakh ha)

Production share FIRST - India (28 %) II - China (22 %)

Indian Tea Industry

- The total turnover of the tea industry is around Rs. 10,000 crores.
- Since independence tea production has grown over 250%, while land area has just grown by 40%.
- There has been a considerable increase in export too in the past few years. Total net foreign exchange earned per annum is around **Rs. 1847 crores**.
- The labour intensive tea industry directly employs over 1.1 million workers and generates income for another 10 million people approximately. Women constitute 50% of the workforce.

Botany

Camellia includes 82 species out of which only two species viz., ***C. assamica*** and ***C. sinensis*** are the original species for tea. As they were highly crossable with each other, the present day tea seedlings (**Jats**) are hybrids of these two species and are often referred as ***C. assamica sub sp lasiocalyx***.

Comparison between Assam and China Jats

Assam Jat	**China Jat**
Camellia assamica	*Camellia sinensis*
Small Tree (1.5-1.8 m ht.)	Big shrub (90-150 cm ht.)
Few robust branches	Abundant, whippy shoots
Large, glossy leaves, 8-20 cm Long, 3.5-7.5 cm wide, Light to medium green	Small, leathery erect leaves, 1.5-14 cm long and 1-2.5 cm Wide, Dark green colour
High yield,	Low yield
Cup quality-medium	Good quality
Less hardy, Susceptible to Drought and frost	Hardy and resistant to Drought and frost
Sparse flowering	Profuse flowering

Tea is an evergreen shrub or tree. Leaves simple, alternate, serrated, flower bisexual, regular, sepals five, petals, five., stamens many, anthers two celled, ovary superior 2-4 locules, ovules 2-4 rarely solitary, axile, fruit is a capsule.

In tea bush under plucking, a proportion of shoots will be actively growing, called as **periodic shoots or flush shoots** and the other shoots which remain temporarily dormant are called as **banji shoots**.

Periodic shoots develop from the axillary bud. It has definite pattern of growth.

Aperiodic shoots develop from pruned bush frame. It grows in steady succession.

The first scale leaf usually drops off with the scar seen at the base of every shoot. A malformed leaf growing like an ordinary leaf is called **'fish leaf'** and has smooth margins and oval shape without prominent tip. Next, the normal leaves unfold in sequence from the growing bud.

4 weeks – sprouting of axillary bud

5-6 weeks – unfolding of scale leaf

6-7 weeks – unfolding of fish leaf

8-13 weeks – formation of pluckable shoot

Varieties

Pandian (UPASI-10), Sundaram (UPASI-3), Golconda (UPASI-8), Jayaram (UPASI-2), Evergreen, Athrey, Brookeland (UPASI-6), Singara (UPASI-14), Spring field (UPASI-15), Swarna (UPASI-17), BSS 1, BSS 2, BSS 3, BSS 4, BSS 5, Biclonal seed stocks and Grafts.

Soil and climate

Temperature required various from 16-32ºC with well distributed annual rain fall of 125-150cm. Atmospheric humidity should be 80%. Tea requires well drained soil with high amount of organic matter and pH 4.5 to 5.5. The performance of tea is excellent at elevations ranging from 1000 - 2500 m above MSL.

Tea is calcifuge crop requiring comparatively low amounts of calcium and high amount of potassium and silicon.

Propagation

Tea is propagated by cuttings.

Nursery

The nursery soil should be well drained and deep loam in nature with pH of 4.5 to 4.8. The soil and sand used in the preparation of rooting medium should be tested for pH and nematode infestation.

Pre-treatment of rooting medium

Treating with Aluminium sulphate can reduce soil pH. For this purpose the nursery soil is formed into beds of one metre width and about 8 cm height and of

a convenient length. Then the beds are drenched with 2% solution of Aluminium sulphate applied at 10 litres/ 2.5 sq.m of area. Over this another layer of soil of 8 cm height is spread and again drenched with equal quantity of water twice. Then the soil is allowed to dry and the pH is checked before use in the nursery.

Preparation of sleeves

Polythene sleeves of 150 or 200 gauge and 10 cm width and 30 - 45 cm length may be used. Drainage holes may be provided at the bottom. The lower 3/4 of the sleeves should be filled with 1:3 and soil mixture and the top 1/4 with 1:1 sand and soil mixture and staked in rows. Overhead shade is provided.

Selection of mother bush and its treatment

Healthy and vigorously growing high yielding bushes should be selected. Apply to each selected bush with 40 g of young tea mixture + 60:90 NK mixture up to 5 years. The following mixture has to apply before taking the cuttings.

- 0.5 % AlSO4 + 1 % MgSO4 (before 3 weeks)
- 2 % Zn SO4 (before 2 weeks)
- 1 % Urea (before 1 week)

Preparation of cuttings

Cuttings are taken on April - May and August - September. Semi hardwood cuttings are prepared with one leaf and an internode with a slanting cut at the bottom. Rooting was more in cuttings taken from two years old clonal plants than the old bush. **Planting of cuttings**

The sleeves are watered thoroughly and holes are made in the soil. The cuttings are inserted in the hole and the soil around is pressed firmly to avoid airspace followed by watering. Small polythene tents may be provided which maintain high humidity and regulate the temperature inside. Cuttings may take 10 - 12 weeks for rooting. After 90 days i.e. when all the cuttings have rooted, the polythene tent may be removed gradually over a period of 10 - 15 days.

Grafting

Even cleft grafting of single nodal cuttings is followed

Manuring of nursery

After the tent is removed the cuttings are sorted and staked. 30 g of Nursery soluble mixture of the following composition dissolved in 10 litres of water may be applied over an area of 4 sq.m. This should be done fortnightly.

Hardening of the cuttings

Hardening of 4 - 6 months old young cuttings should be done by removing shade gradually in stages over a period of 4 - 6 weeks starting from a few hours exposure to sun every day initially and extending the time of exposure gradually. **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.

Season and planting - May - June or September - October

Irrigation

Subsoil irrigation may be given for young tea seedlings during summer months.

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
	N	K	
I year	180	270	5
II year	240	360	6
III year	300	450	6

IV year onwards	300	300	6

Application of fertilizers should be done before the onset of monsoon. Fertilizers should be broadcast around the drip circle avoiding contact with the collar.

After cultivation

Mulching

Covering the soil surface with any material is recommended. While mulching, care should be taken to keep the mulching material away from the collar region of the plants it reduces soil erosion, conserves soil moisture, suppresses weed growth and adds organic matter.

Weed control

Perennial grasses can be controlled by spraying Glyphosate 1.75 lit + Kaoline 2 lit + 2 kg of wetting agent in 450 lit. of water followed by Gramoxone 500 ml in 200 lit of water to control dicot weeds.

Liming

In hill soils due to leaching of bases by rain and due to application of acid forming fertilizers, often soil pH is reduced. Hence periodical application of lime is essential to maintain optimum pH. Calcium carbonate or Dolomite is applied @ 1.5 t/ha prior to pruning (also depends on soil pH, rainfall, fertilizer usage and length of the pruning cycle).

Shade and its management

Tea requires filtered shade and if it is exposed to direct sun, its growth is affected. Shade is hence essential and beneficial to tea as

1. It regulates the temperature.
2. It minimizes the effects of drought and radiation injury.
3. It increases the soil fertility (leaf litter adds about 8-10 tonnes of organic matter per ha/year).

4. It helps in recycling of nutrients.
5. It helps in getting even distribution of crop.
6. It serves as wind break.
7. It reduces the incidences of pests.
8. It generates additional income by way of timber and fuel. **Drawbacks of shade**

1) Increased incidence of blister blight
2) Competition with main crop for moisture and nutrients 3) Reduced response to applied fertilizers.

In South India, Silver oak (*Grevellia robusta*) is used as the permanent shade tree as it possesses the desirable characters of a good shade tree like

1. It must be an evergreen tree, easy to propagate having quick growing and deep rooted characters.
2. It provides filtered shade and withstands frequent lopping.
3. It tolerates wind and frost.
4. It does not have allelopathic effect.
5. It has commercial timber value also.

Pollarding

Six to nine months old seedlings are ready for planting. Silver oak seedlings are initially planted along the tea rows at 6m x 6m spacing. As and when they grow, lower branches may be lifted periodically. When it attains 8 to 9m height, the tree is pollarded at a site having a girth of 10 to 15cm. Below the pollarded site, one branch in each direction may be left in 3 to 4 tiers and the excess ones are removed. Before every monsoon, the lateral branches, erect growing branches and shoot growth in the main stem are removed.

Training young tea

Cantering

To induce more laterals, cantering should be done 3 - 5 months after planting. Removing the growing point leaving 8 to 10 mature leaves from the bottom is done to induce secondaries.

Tipping

Tipping is done at a height of 35 cm from the second tipping at 60 cm from ground level.

When the secondaries reach more than 60 cm, they are tipped at 50-55 cm height by removing 3 to 4 leaves and bud to induce tertiaries. Therefore, plucking at mother leaf stage is continued for better frame development. It takes nearly 18 to 20 months from planting to reach regular plucking.

Pruning

Normally tea bushes establish themselves within a month of planting. In the course of one year or sometimes 18 months, they reach a height of 60-75 cm. After this stage, pruning may be taken up with the following objectives:

1) To minimize the height for purpose of easy plucking young buds, leaves and shoots.
2) To maintain the plant permanently in a vegetative phase.
3) To stimulate the production of young shoots

Pruning is normally done 4 to 6 years interval depending upon the altitude of the garden, nature of the tea materials etc. The bushes marked for pruning should have adequate starch reserves in roots otherwise the sprouting following pruning will be less. This can be normally tested by the common Iodine test and if the starch reserve is less, bushes are allowed to rest for 2 to 3 months.

The different types of pruning are as follows

Type of pruning	Pruning height (cm)	Season	Remarks

1.	Rejuvenation pruning	20 (China Jat) 30 (Assam Jat)	April-May	Done in old bushes affected with canker and wood rot to invigorate the new healthy branches. Not done regularly.
2.	Hard pruning	30-45	Apr - May	First formative pruning done to a young tea for proper spread of bushes
3.	Medium pruning	45-60	Aug-Sept.	Normal pruning wherever frames are healthy to stimulate new wood
4.	Light pruning	60-65	Aug-Sept.	Pruning depends on the previous history of the bush raising the height of medium pruning by an inch or less to manageable heights for plucking (less than 65 cm).
5.	Skiffing	65	Aug-Sept.	This is the lightest of all pruning methods. A removal of only the top 5 - 8 cm new growth is done so as to obtain a uniform level of pruning surface (more than 65 cm).

Area to be pruned every year = $\frac{\text{Total extent of the garden}}{\text{Pruning cycle}}$

Pruning interval = (Elevation in feet / 1000) + 1

Pruning should be done in April - May or August - September

Immediately after the rejuvenation or hard pruning, the cut ends are smeared with a paste made of copper oxychloride and linseed oil (1:1).

Plucking

Plucking consists of harvesting 2 to 3 leaves and a bud. It is the most labour intensive operation in a tea industry and also decides the yield and quality of made tea. Normally, a pluckable shoot takes 60 to 90 days for harvesting since its sprouting from the axillary buds. When the shoot is plucked upto mother leaf, it is known as **light plucking** and if it is plucked below mother leaf, it is called **hard plucking**.

Plucking 'two leaves and a bud' is known as **'full'** and anything less than this is known as '**fine**'. Inclusion of more than two leaves is termed as '**coarse**'. **The younger the leaves, more is the tannin content and hence the superior quality tea.**

Plucking interval and plucking standard in relation to cropping is given below:-

Cropping pattern	**Months**	**Plucking interval**
High cropping or Rush cropping (60% of total crop)	April – June and October -December	7 – 10 days
Low cropping or lean cropping (40% of total crop)	July – September and January - March	12 – 15 days

It is essential to add one tier of active maintenance foliage to the bush every year. This is done by **mother leaf plucking during January to March**. During the rest of the period level plucking can be carried out.

Consequent to plucking, bush height increases every year in the order of 10 cm over tipping height in the first year, 7.5 cm, 7.5 cm, 5 cm and 5 cm over the previous year height in the second, third, fourth and fifth year respectively.

In some places, a scissor like **mechanical shear harvester** is employed to pluck during the high cropping period. It helps to manage the high crop and overcome labour scarcity.

Plant protection

Scales

Scales can be controlled by spraying Carbaryl 50 WP @ 2 g/lit.

Thrips and Aphids

Thrips and Aphids can be controlled by spraying Phosalone 35 EC

Mites

Mites can be controlled by spraying Dicofol 18.5 EC @ 2 ml/lit

Diseases

Blister blight

Blister blight can be controlled by adopting the following control measures.

- Spray 210 g Copper oxychloride and Nickel chloride per ha at 5 days interval from June - September; 11 days intervals in October and November.
- Spray Hexagonazole 200 ml + Copper oxychloride 210 g /ha at 5 days interval

Yield

Yield of made tea per hectare depends upon many factors such as elevation, clonal or seedling Jats, management practices, severity of pruning, processing techniques etc., In general in tea industry, a field yielding upto 2000 kg of made tea/ha is considered as low yielding and 2000 to 3000 kg. as medium yielding and anything above 3000 kg as high yielding fields.

Manufacturing of tea Types

of processing

1. **Orthodox method** in which the rolling operation is done in a series of rollers.
2. **CTC method** (cutting, tearing and curling) which has a CTC machine, consisting of series of a pair of rollers mounted in such a way they rotate in opposite directions

Steps

1. Withering

The objective of withering is to reduce the moisture content of leaves by spreading them in troughs which receive artificial air from fan fitted on one end. At the end of withering, the leaves attain a flaccid condition for which it may take 12 to 18 hours depending upon the weather condition.

2. Rolling

This operation is carried on by a series of machines or in a single roller, during which the cells in the leaves are broken to liberate the sap containing the enzyme polyphenol oxidase, This enzyme oxidizes the polyphenols to produce **theaflavins** and **thearubigens**. These are **responsible for colouring of the tea** and are a prerequisite for next process *viz.,* fermentation. Rolling takes place for 30-40 minutes. Afterwards, the fine sifted rolled ones are sent for fermentation while the coarse ones are again sent for rolling.

3. Fermentation

Rolled tea materials are either spread in concrete floors or kept in aluminium trays. In the presence of high humidity and proper temperature, the properly fermented tea will take golden red colour. **This step decides the quality i.e. Strength, colour and briskness of tea.** Fermentation requires 1 hour or 2 hours depending upon the environmental conditions.

4. Drying

This step aims at stopping the fermentation process and slowly removing the moisture content without a burnt smell. This is achieved by passing the fermented tea in thin layers through conveyors into a drier in which the inlet temperature is maintained around 250-280^{o}F and outlet temperature is a round 150-200^{o}F. Proper drying takes 30-40 minutes.

5. Grading

Before grading, the dried tea is removed of the stalky fibres, which affect the quality, by passing through fibre separator machines. The bulk tea is passed through different sized meshes which aid in separation into different grades.

Orthodox grades	Mesh size	CTC Grades	Mesh size

1.	Pekoe	>8	Flowery Pekoe (FP)	>8 mesh
2.	Tippy Golden Orange Pekoe (TGOP)	8-12	Pekoe	8-10
3.	Broken Orange Pekoe (BOP)	12-16	BOP	10-12
4.	BOP-Fannings	16-18	Pekoe Fannings	12-16
5.	BOP-dust	18-24	BOP-Fannings	16-20
6.	Dust-I	25-30	Pekoe Dust (PD)	20-30
7.	Dust-II	Below 30	Red Dust (RD)	30-40
8.			Super Red Dust (SRD)	40-50
9.			Fine Dust (PD)	50-60
10.			Superfine Dust (SD)	Below 60

Green tea

In green tea manufacture, the leaves after harvest are heated as quickly as possible which inactivates the oxidizing enzymes. Then they are cooled and rolled by further heating and rolling and eventually dried to 4% moisture.

Non-withered tea

In this process, no withering is done. Firing becomes difficult and fermentation is incomplete leading to unfermented catechins and bitter taste.

But it has good strength, colour and bright and uniform infusion.

Pickled tea

Pickled tea is valued as a masticator in Burma. Wet leaves are tightly packed into mortar lined pits, compressed and made as silage.

Instant tea

Water soluble extract of black tea is spray dried to powder form. It has high export potential.

Caffeine free tea

Caffeine from tea is removed by organic solvents and decaffeinated tea is marketed.

Oolong tea

Oolong tea is semi or 50% fermented and contains polyphenol dimmers. It is produced only in China.

Silver tips tea

Silver tips are generally produced by plucking only buds and drying them in natural sunlight.

Handmade tea

Handmade tea is processed from shoots containing only one or two leaves and a bud. **Herbal tea/Flavoured tea/Scented tea**

Green tea is mixed with medicinal plants, flavoured tea mixed with flavours of cardamom, bergamot mint etc. and scented tea mixed with jasmine flowers

TEA

Tea belongs to the family Camelliaceae and all the cultivated tea plants belong to two distinct species,

viz., Camellia sinensis, the short leaved 'China' plants Camellia assamica, the broad leaved 'Assam' plants.

Tea is commonly consumed as a stimulant and as a refreshing drink at different times of the day. Besides its immediate benefits, tea provides invaluable long term benefits to the human body,

Possess remarkable disease fighting properties.

- Black tea is also a vital defence against cancer and cardiovascular diseases. It has L Theanine, which improves alpha brain wave activity, thereby aiding in relaxation and bringing down stress.

Just like black tea, green tea is also rich in antioxidant polyphenols - catechins, flavonols, theaflavins and thearubigins

	Area (ha)	Production million kg
China	1.1 million	980
India	567000	900
Kenya	122236	303
Srilanka	187500	295

In India, tea cultivation is concentrated in two widely separated traditional regions in the north east and south India.

Assam, West Bengal and Tripura in North-east, certain pockets of Himachal Pradesh and Uttaranchal.

Tea is grown in 16 states in India.

Assam, West Bengal, Tamil Nadu, and Kerala account for about 95 per cent of total tea production.
The Largest state with area under Tea Plantations in India is Assam.

Tea Growing Areas in south India

1	**Wayanad (Kerala)**
2	The Nilgiris (Tamil Nadu)
3	The Anamalais (Coimbatore District, Tamil Nadu)

Nelliampathy (Palghat, Kerala)

High Range (Idukki District, Kerala)

Vandiperiyar and Peermade (Idukki District, Kerala)

High Wavys (Madurai District, Tamil Nadu)

Trivandrum (Kerala)

Singampatty (Tirunelveli, Tamil Nadu)

Coorg (Karnataka)

Hassan (Karnataka)

Chikmagalur (Karnataka)

TEA cultivars with special characters

S.No	Special characters	Clone	Originators
1	Wind Tolerance	UPASI-2 UPASI-10	UPASI-TRF India
2	Drought resistance	UPASI-9	UPASI-TRF India
3	Frost resistance	B-26	HPKV-TES India
4	Smallest leaf	CH-1	IHBT India
5	Biggest Leaf	Betjan	BETJAN T.E, India
6	Water logging tolerance	TV 9	TES, India

21	1	UPASI 1 (Ever green)	Hardy, Quality-Above average	2	UPASI	2
22		(Jayaram)	Hardy, Quality-Above average, tolerant to			
23			drought and wind			

3	UPASI 3 (Sundaram)	Natural triploid quality clones and very high yielding
4	UPASI 6 (Brook lands)	Suited to mid and higher elevations
5	UPASI 8 (Golconda)	Suited to all elevations, high yielding
6	UPASI 9 (Arthrey)	Firly tolerant to drought and withstand slightly high pH, , high yielding
7	UPASI 10 (Pandian)	Hardy, Quality-Above average, tolerant to drought and wind
8	UPASI 14 (Singara)	Suited to higher elevations , High yield
9	**UPASI 15 (Spring field)**	**Flushes throughout the year**
10	UPASI 17 (Swarna)	Flourishing well at mid and high elevations
11	UPASI 24	Hardy
12	UPASI 25	High yielding
13	UPASI 16	High yielding
14	UPASI 27	Drought tolerant
15	UPASI 28 (UPASI 10 * TRI2025)	Biclonal, Good strength and high quality

Soil and climate

Tea requires well drained soil with high amount of organic matter and pH 4.5 to

5.5.

The performance of tea is excellent at elevations ranging from 1000 - 2500 m.

Optimum temperature: 20 - 27^0 C

Nursery

The nursery soil should be well drained and deep loam in nature with pH of 4.5 to 4.8.

The soil and sand of rooting medium should be tested for pH and nematode infestation

Pre-treatment of rooting medium

Treating with Aluminium sulphate can reduce soil pH.

For this purpose the nursery soil is formed into beds of one metre width and about 8 cm height and of a convenient length.

Then the beds are drenched with 2% solution of Aluminium sulphate applied at 10 litres/2.5 sq.m of area.

Over this another layer of soil of 8 cm height is spread and again drenched with equal quantity of water twice.

Then the soil is allowed to dry and the pH is checked before use in the nursery.

- **Preparation of sleeves**

  Polythene sleeves of 150 or 200 gauge and 10 cm width and 30 - 45 cm length may be used.
- Drainage holes may be provided at the bottom.
- The lower 3/4 of the sleeves should be filled with 1:3 sand and soil mixture and the top 1/4 with 1:1 sand and soil mixture and staked in rows.
- Overhead shade is provided.
- **Selection of mother bush and its treatment**

  Healthy and vigorously growing high yielding bushes should be selected.
- Apply to each selected bush with 40 g of young tea mixture + 60:90 NK mixture up to 5 years.

- The following mixture has to applied before taking the cuttings.
- 0.5 % AlSO4 + 1 % MgSO4 (before 3 weeks)
- 2 % Zn SO4 (before 2 weeks)
- 1 % Urea (before 1 week)
- **Preparation of cuttings**
- Cuttings are taken on April - May and August - September.
- Semi hard-wood cuttings are prepared with one leaf and an internode with a slanting cut at the bottom.
- **Planting of cuttings**

  The sleeves are watered thoroughly and holes are made in the soil.
- The cuttings are inserted in the hole and the soil around is pressed firmly to avoid airspace followed by watering.
- Small polythene tents may be provided which maintain high humidity and regulate the temperature inside.
- Cuttings may take 10 - 12 weeks for rooting.
- After 90 days i.e. when all the cuttings have rooted, the polythene tent may be removed gradually over a period of 10 - 15 days.
- **Manuring of nursery**

  After the tent is removed the cuttings are sorted and staked.
- 30 g of Nursery soluble mixture of the following composition dissolved in 10 litres of water may be applied over an area of 4 sq.m. This should be done fortnightly.
- **Composition of the fertilizer**

Ammonium phosphate (20:20)	35 parts by Wt
Potassium sulphate	15 parts by Wt
(or)	
MOP	12 parts by Wt
Magnesium sulphate	15 parts by Wt
Zinc sulphate	3 parts by Wt

Total	**80 parts by Wt**

- **Hardening of the cuttings**

  Hardening of 4 - 6 months old young cuttings should be done by removing shade gradually in stages

Over a period of 4 - 6 weeks starting from a few hours exposure to sun every day initially and extending the time of exposure gradually.

- **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.

Season and planting

May - June or September - October

Sleeves should be opened lengthwise without injuring the roots and planted in the pit and the soil is gently pressed.

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 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.

Total weight kg/ha/annum		**Qty/plant**	
No. of applications	**Ammonium Sulphate**		
	Urea		
5	13	27	

			6	23	15
			6	29	18
			6	33	19

Year of application	N	K
I year	180	270
II year	240	360
III year	300	450
IV year onwards	300	300

Application of fertilizers should be done before the onset of monsoon. Fertilizers should be broadcast around the drip circle avoiding contact with the collar.

Aftercultivation

Perennial grasses (Forbicot weeds) can be controlled by spraying Glyphosate 1.75 lit + Kaoline 2 lit + 2 kg of wetting agent in 450 lit. of water followed by Gramoxone 500 ml in 200 lit of water to control dicot weeds.

Training young tea

Centering

To induce more laterals, centering should be done 3 - 5 months after planting. The main leader stem should be cut, leaving 8 - 10 matured leaves.

Tipping

Tipping is done at a height of 35 cm & second tipping at 60 cm from ground level.

Pruning

Pruning is done to maintain convenient height of bush and to remove dead and diseased branches.

Area to be pruned every year = Total extent of the garden/ Pruning cycle

Pruning interval = (Elevation in feet / 1000) + 1

Pruning should be done in April - May or August – September

Rejuvenation pruning

The whole bush should be cut near the ground level less than 30 cm with a view to rejuvenate the bushes.

Hard pruning

Hard/ formation pruning of young tea is done at 30 to 45 cm (12" to 18") for proper spread of bushes.

Medium pruning

To check the bush growing to an inconvenient height this type of pruning is done in order to stimulate new wood and to maintain the foliage at lower levels less than 60 cm.

Light pruning

Pruning depends on the previous history of the bush raising the height of medium pruning by an inch or less to manageable heights for plucking (less than 65 cm).

Skiffing

This is the lightest of all pruning methods. A removal of only the top 5 - 8 cm new growth is done so as to obtain a uniform level of pruning surface (more than 65 cm). **Shade regulation**

Pollarding of shade trees should be done prior to heavy rains at a height of 8 - 10 m from the ground level

Annual lopping

Cutting the erect type branches on the laterals in shade trees before monsoon season

- Plucking commences when the tea bush is 3 years old.

- The plucking of extreme tip of the growing branch consists of an unopened bud together with two leaves is popularly known as "Two leaves and a bud"
- In South India plucking continues throughout the year at weekly intervals during March - May and
- At intervals of 10 -14 days during the other months.
- **Rush period**

  During rush period harvesting is done at 7 to 10 days interval.
- **Lean period**

  During lean period harvesting is done at 10 – 15 days interval.

Yield

The yield of green leaves is 10 t/ha

Tea Board

The present Tea Board is functioning as a statutory body of the Central Government under the Ministry of Commerce. The Board is constituted of 31 members (including Chairman) drawn from Members of Parliament, tea producers, tea traders, tea brokers, consumers, and representatives of Governments from the principal tea producing states, and trade unions . The Board is reconstituted every three years.

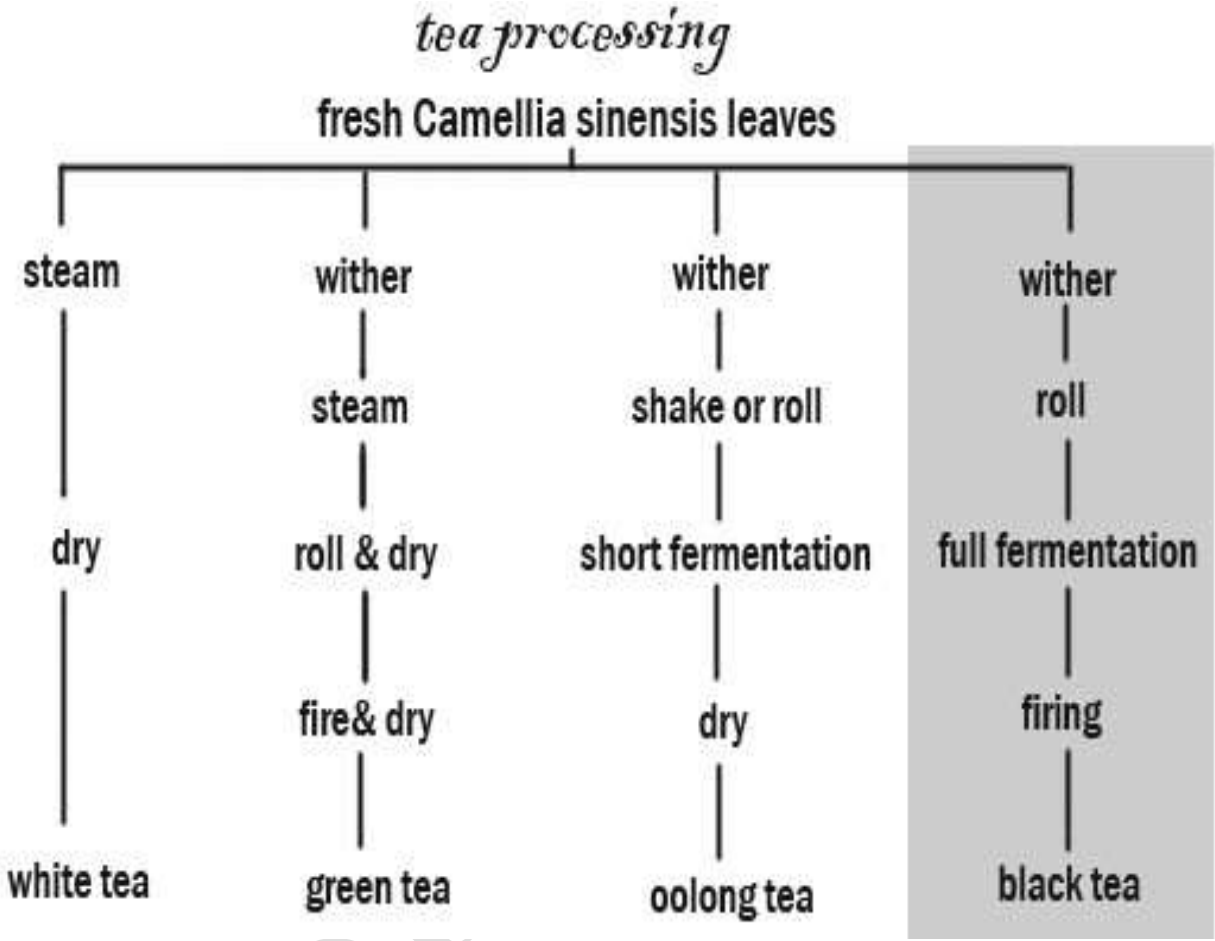
TANTEA- Tamilnadu Tea Plantation Corporation Limited (an undertaking of the State Government of Tamilnadu, India)

TANTEA is one of the biggest Black Tea producer in India with high quality clonal tea plantations spread over nearly 4500 ha. In Nilgiris and Coimbatore districts of Tamilnadu

Tea processing

Tea processing is the method in which the leaves from the tea plant *Camellia sinensis* are transformed into the dried leaves for brewing tea. The categories of tea are distinguished by the processing they undergo. The innate flavour of the

dried tea leaves is determined by the type of cultivar of the tea bush, the quality of the plucked tea leaves, and the manner and quality of the production processing they undergo



Two types of processing.,

Orthodox method

CTC method

Orthodox method

In this rolling operation is done in a series of roller. The rollers have rotary tables with battens, jacket for loading the leaf &a pressure cup.

CTC method (cutting, tearing & curling):

It is a CTC machine consisting of series of a pair of roller mounted in such a way they rotate in opposite directions &the clearance them is so adjusted to crush &tear the leaves.

Tea leaf processing methods

Plucking

Withering/ Wilting

Disruption

Oxidation / Fermentation

Fixation / Kill-green

Sweltering / Yellowing

Rolling / Shaping

Drying

Aging / Curing

Plucking

Tea leaves and flushes, which include a terminal bud and two young leaves, are picked from *Camellia sinensis* bushes typically twice a year during early spring and early summer or late spring.

Picking is done by hand when a higher quality tea is needed, or where labour costs are not prohibitive.

Tea flushes and leaves can also be picked by machine, though there will be more broken leaves and partial flushes reducing the quality of the tea.

Withering/ Wilting

The tea leaves will begin to wilt soon after picking, with a gradual onset of *enzymatic oxidation.*

Withering is used to remove excess water from the leaves and allows a very slight amount of oxidation.

The process is also important in promoting the breakdown of leaf proteins into free amino acids and increases the availability of freed caffeine, both of which change the taste of the tea.

Disruption

The leaves may be lightly bruised on their edges by shaking and tossing in a bamboo tray or tumbling in baskets. More extensive leaf disruption can be done by kneading, rolling, tearing, and crushing, usually by machinery.

The bruising breaks down the structures inside and outside of the leaf cells and allows from the co-mingling of oxidative enzymes with various substrates, which allows for the beginning of oxidation.

Oxidation / Fermentation

In this process the chlorophyll in the leaves is enzymatically broken down, and its tannins are released or transformed. This process is sometimes referred to as "fermentation" in the tea industry

Fixation / Kill-green

Kill-green or Fixation is done to stop the tea leaf oxidation at a desired level. This process is accomplished by moderately heating tea leaves, thus deactivating their oxidative enzymes and removing unwanted scents in the leaves, without damaging the flavour of the tea.

Sweltering / Yellowing

Unique to yellow teas, warm and damp tea leaves from after kill-green are allowed to be lightly heated in a closed container, which causes the previously green leaves to turn yellow.

The resulting leaves produce a beverage that has a distinctive yellowish-green hue due to transformations of the leaf chlorophyll.

Rolling / Shaping

The damp tea leaves are then rolled to be formed into wrinkled strips, by hand or using a rolling machine which causes the tea to wrap around itself.

This rolling action also causes some of the sap, essential oils, and juices inside the leaves to ooze out, which further enhances the taste of the tea.

Drying

Drying is done to "finish" the tea for sale. This can be done in a myriad of ways including panning, sunning, air drying, or baking.

The drying of the produced tea is responsible for many new flavour compounds particularly important in green teas.

Aging / Curing

While not always required, some teas required additional aging, secondary fermentation, or baking to reach their drinking potential.

Grading

Before grading, the dried tea is removed of the stalky fibres which effect the quality by passing through fibre separator machine.

The bulk tea is passed through different sized meshes which aid in separation into different grades.

Orthodox grades:

Pekoe, Dust-1, Dust-11, BOP-dust, BOP-Fanning, Tippy golden Orange Pekoe (TGOP), and Broken Orange Pekoe (BOP).

CTC grades

Flowery pekoe (FP)

Pekoe

BOP

Pekoe fanning

BOP-fanning

Pekoe Dust (PD)

Red Dust(RD)

Super Red Dust (SRD)

Fine Dust(FD)

Rubber (*Hevea brasiliensis)*

Euphorbiaceae

Named by British scientist as it erases pencil marks. Rubber is a byproduct of cell metabolism.

Most plants of Euphorbiaceae & some plants of compositar produce rubber. *Pathenium argentatum (*C.A) gives Guayule rubber.

Origin:

During 19th century it spread to South East Asia. In India during 1905 it was introduced into Kerala. Now mainly grown in tropical regions. Malaysia, Indonesia, India, Sri Lanka & other South East Asian countries.

Major areas: Indonesia (25 lakh ha)

Major producer: Thailand (25 lakh MT)

In India (4 lakh ha, 3 lakh MT) 90% of rubber is produced in Kerala and Kanyakumari. India is not self-sufficient. 60% of demand is met by import.

Major consumers: USA, China, Japan, India.

Composition:

Yellow coloured opaque liquid. Natural rubber is obtained by latex, which has 30-40% rubber ash, with 60% water, protein, sugar, gum, tennin, pectin etc. These have stabilizing influence on rubber.

Uses:

Auto tyres and tubes- 45%

Cycle tyres and tubes- 13%

Camel black, belts, hoses- 12%

Foot wares- 11%

Latex foams- 5%

Others:

Shock absorbers, washers, gaskets, sports goods, contraceptives, household & hospital materials, paints, electronic, electrical, radio appliances.

Bitumin rubber powder- Road surfacing **Botany:**

Ever green tree, 18-30m height. Upright growth with crown like canopy. Wood is covered by bark, which on tapping yields latex. The cambium between bark

and wood is responsible for increasing the girth of the tree as well as bark renewal. Moths, bees, flies are pollination agents.

Hevea:

Prior to introduction of rubber plantation in South East Asia, the demand was met by wild American *Hevea sp.* Such as *Hevea benthamiana, H. Guianensis*.

Cultivars: Rubber Research Institute of India

Varieties	Yield	Special attributes
RRII- 105	Yield: 2460kg/ha/yr	Susceptible to drought.
RRIM- 600 (Rubber Research Institute of Malaysia)	1200 kg/ha	Tolerant to wind damage
RRIM- 703	1700 kg/ha	Tolerant to powdery mildew
GT-1, Indonesia	-	Thick bark

Soil: Hardy, pH 5.5 to 6.5, Sandy loam, forest loam & laterite soils ideal. Alkaline soil- Stunted growth.

Climate: Temp 20-28^{o} C , RF- 180 to 200cm/ann upto 600m, RH 80%, moderate wind & bright sunshine.

Propagation:

Seed and bud grafting. Buds taken from high yielding trees grafted on seedlings.

Brown budding- Bud wood one year old, root stock 10 months old seedling.

Green budding- Green buds used on 2-8 months old seedling.

Crown budding- If clones are susceptible to disease/ wind, used for replacing clones. Done at 2 to 2.5 m height.

Spacing: 5mX6m

Population Buddings – 170 to 180 plants/ac

Seedlings- 180 to 210 plants/ ac

Initial population is high, selective thinning is done to get 134 plants/ac. One vigorous shoot is allowed to grow. Side shoots upto 3m should be removed.

Cover crops: to prevent soil erosion.

Calapagonium mucunoides, Mucuna bracteates **Shade :**

Albizzia & Gliricidia are used.

Fertiliser:

NPK 40:90:90 g/plant/ year. Two splits May- June & Sep to Oct.

Pest and Disease:

Leaf fall: During south west monsoon due to fungal attack in leaf petioles. COC (Copper oxy chloride) spray at 0.25%.

Pink disease: Attacks stem- Exudation of latex, drip & run along stem. Mycelium forms "Cobweb" prolongs immaturing period. Spray- Bordeaux mixture.

Powdery mildew: Wettable sulfur.

Pests: Scales, Mealy bug, termites.

Harvest:

Tapping commences from 6-7 years of planting, when 70% trees are with 50-55cm girth.

Tapping: Controlled wounding- Thin shavings of barks are removed to obtained latex from the bark. Tapping is done to cut open the latex vessels (first time) or to remove coagulum which blocks the end of latex vessels during subsequent tapping.

Tapping height:

Budded plant at 50cm girth , 125cm from bud union.

Seedlings at 50cm girth 90cm height from ground.

1/30 or 1/20 inches of bark is removed at regular intervals. Cut extends half way round the trunk.

- Half spiral system- 25- 30^{o} to horizontal
- Full spiral system

- V- cut system
- Herring bone system

- Depth – 1mm close to cambium, no injury to cambium (more latex vessels).
- Left to right is best,
- latex flow stops in 1-3 hours and plugged with coagulum,
- Bark consumption is 20-30 cm / year.
- 250 to 300 trees tapped / one person/day.

Tapping intensity:

Quarter cut tapped daily is 100 %(standard)

South India, 1. Half spiral system S/2

2. Alternate day tapping d/2

3. 100% are employed.

Tapping knife: "Miche Golledge"

GR: Latex reduces ofter 4-5 years. Ethephon at 10% a.i. is used to increase latex flow. Diluted with palm oil/ coconut oil/ water and smeared **at** cut end with brush after light scraping. Ethephon delays plugging.

Tapping cups:

i. Earthen ware- mostly used, cheap & heavy

ii. Glass, plastic (expensive, broken)- Rubber sticks to the cup.

iii. Cups are tied with wire and sprout is fixed to direct latex flow to cup.

Slaughter tapping:

Before felling the tree for 2-3 years tapping intensity is increased without considering bark consumption and cambium wounding. Yd. stimulants are also used.

Yield: Depends on volume of latex and % of rubber in latex.

Average yield- 850-2500 kg/ha/yr.

- Peak production – 15 years,
- Should be replaced in 30 years.

- Fresh latex is alkaline
- It becomes acidic rapidly due to bacterial action & coagulates. Anti- coagulants- Ammonia 0.01%, sodium sulphate- 0.05%, formaldehyde-

0.02%.