COFFEE

Dr Bhawna Kaushal
Assistant Professor
Department of Zoology and Environmental Sciences SBAS
Course name: Economic Botany
Course no.: BGE-202B

Kingdom classification of Coffee

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Rubiales

Family - Rubiaceae

Genus - Coffea

Species - arabica and canephora

Introduction and uses of coffee

- Coffee is the 2nd important commodity in the world trade after petroleum product
- It is a brewed drink prepared from roasted coffee beans which are the seeds of berries from the coffea plant.
- It ican be dark brown , light brown or black in colour
- It is loaded with antioxidants and beneficial nutrients like riboflavin , magneese and potassium etc.
- It can help people to feel less tired and increase energy levels because it contains a stimulant called **Caffeine**
- It lowers the risk of diabetes
- It has protective effect on liver

Brief History of Coffee

Origin:-

- Coffee's origin can be traced to the 12th century in Ethiopia, where it is believed to have been first harvested.
- "Traders brought coffee to the Middle East, from where it began to spread outward in the 15th century, penetrating every corner of Europe over the next two hundred years".
- Coffee became a very important means of European trade as it spread to the Dutch's, French's, and British's colonies during the 18th and 19th century.
- At this time, people from Africa and natives of the colonies were enslaved to work in the coffee plantations.
- "During the period of decolonization, coffee was put forward as a miracle crop that would allow developing countries to achieve economic growth."

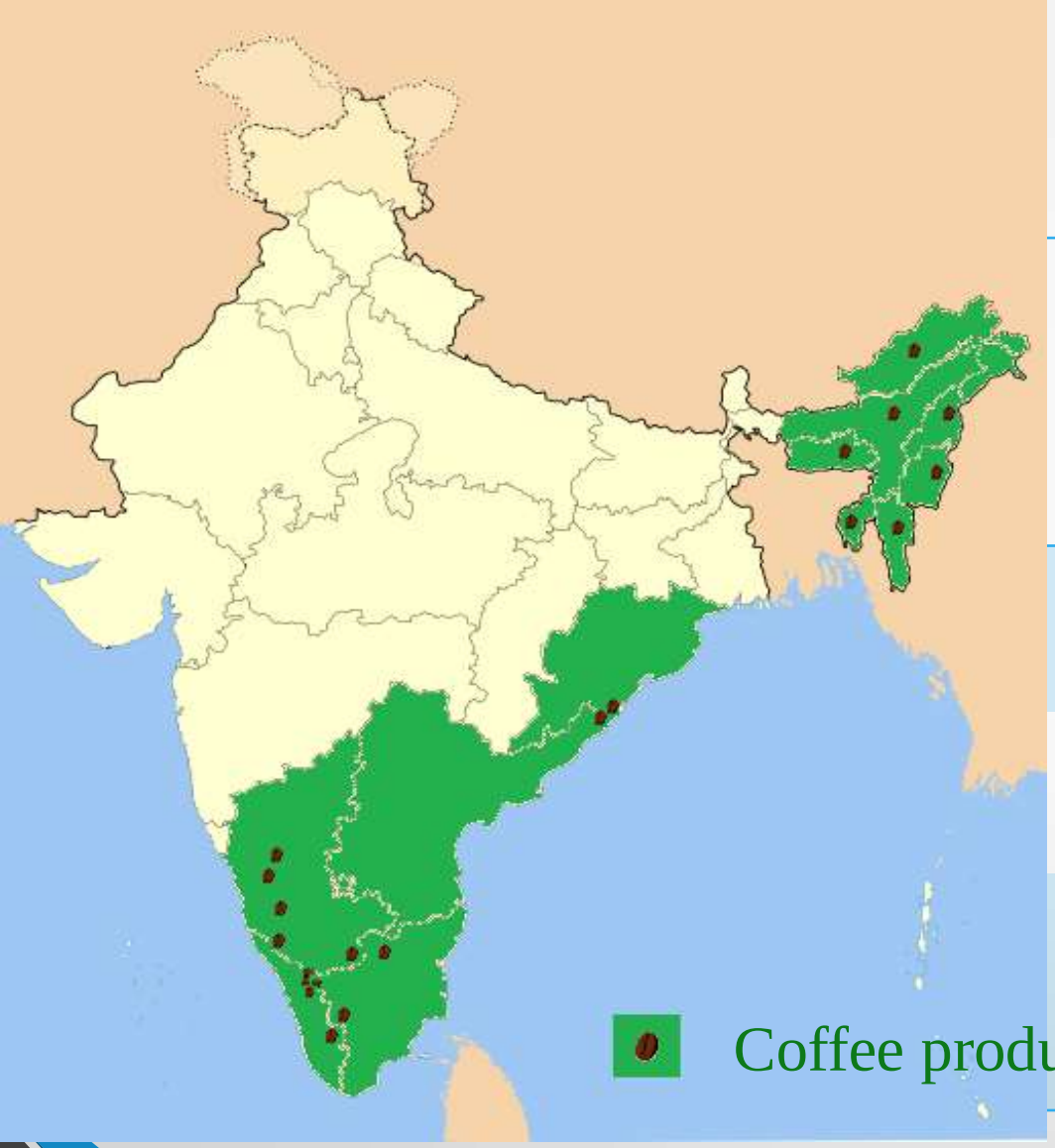
World Coffee Production

- **Brazil**
  - **21.1%, arabica**
  - **Only country with frost possibility in coffee zone**
- **Colombia**
  - **13.9%, arabica**
- **Indonesia**
  - **7.3%, robusta**
- **Other important producing countries**
  - **Vietnam, Mexico, Ethiopia, India, Guatemala, Ivory Coast, Uganda**

Sl.No. /Position	Country	Percent of world area under coffee
1	Brazil	21.2
2	Ivory Coast	12.3
3	Columbia	9.9
4	Indonesia	9.1
5	Mexico	5.2
6	Angola	4.5
7	Uganda	3.5
8	India	2.6
9	Other countries	31.8
	Total	100

Total area under coffee : 11.6 million ha.

Coffee production in India



Total area under cultivation of Coffee in India	**333,000 ha**
Total production of coffee	**276,350 MT**
Main coffee type	#1 **Arabica** #2 **Robusta**
Largest Coffee producing state:	**Karnataka** 183,100 ha (Area) 182,500 MT(Production)

Area under coffee in India (2.60 per cent of world acrage (8th position in the world) Accounts for 3 per cent of world coffee production. area.

MAJOR CONSUMERS

- **High proportion imported by developed countries**
  - **USA 23%**
  - **EEC 39%**

Botanical Description

- Coffee plant is a woody evergreen shrub and grows in wild as high as 12m but cultivated trees are pruned to 2m
- Coffee plants have bright green opposite leaves with smooth margins
- Small, white flowers give rise to a red fleshy fruit , the red cherry

Coffee Tree Growth Cycle

- Dry and/or cool season
  - Floral initiation
  - Reduced vegetative growth
- Wet season
  - Flowers open, fruit set and begin development
  - Active vegetative growth
- Dry and/or cool season
  - Fruit ripen
  - Flower buds initiate
  - Reduced vegetative growth

Coffee Tree Growth Habit

- **Orthotropic stem**
  - Erect growth
- **Plagiotropic stems**
  - Horizontal secondary stems growing off of orthotropic stems
  - These are the fruiting wood

The Seed of the Fruit is the Economic Part

A Drupe like a Peach

- Both begin bearing in 3-4 years
- Time to mature fruit
  - Arabica, 7-8 months
  - Robusta, 11-12 months
- Productive for 20-30 years
- Both need pruning for best production

The Coffee Fruit is called a Cherry

- Exocarp
  - Red skin
- Mesocarp
  - Sweet pulp
- Endocarp, hull
  - Testa (silvery)
  - Bean (embryo and cotyledons)
  - Parchment coffee is the bean, testa, endocarp

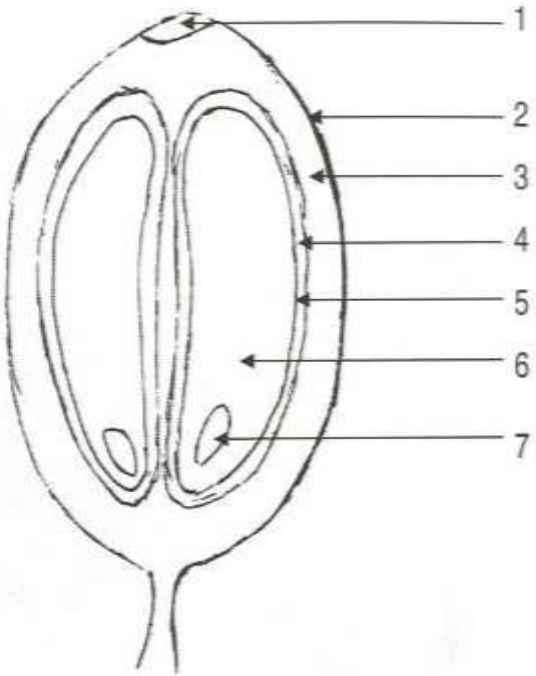
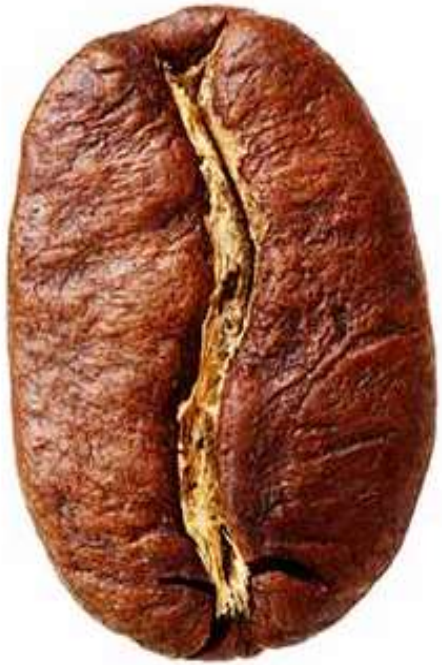


Fig. 4.6. Cross-section of coffee cherry. 1, Disc (navel); 2, exocarp (skin); 3, mesocarp (pulp); 4, endocarp (hull, parchment); 5, testa (silverskin); 6, cotyledon (bean); 7, embryo.

Two Types of Coffee



Arabica, *C. arabica*

- **Tetraploid, self fertile**
- **Ethiopia highlands**
  - **>1600m**
  - **15-24°C**
  - **1300 mm**
- **Best quality**

Susceptible to rust

Robusta, *C. canephora*

- **Diploid, self incompatible**
- **Rain forest of Congo basin**
  - **<750m**
  - **24-30°C**
  - **1550 mm**
- **Less flavor, acidity**
- **Resistant to rust**

Arabica, *C. arabica*

- **Medium size tree**
  - **14-20’ tall**
- **Medium vigor**
- **Leaves**
  - **Smaller**
  - **Thinner**
- **Seedlings uniform**

Robusta, *C. canephora*

- **Medium to large tree**
  - **Up to 32’ tall**
- **Vigorous**
- **Leaves**
  - **Larger**
  - **Thicker**
- **Seedlings variable**

Coffee arabica

Coffee robusta

Soil and climatic requirement

Soil: Coffee is not very specific with respect to its soil requirements. Important features of ideal soil for profitable coffee cultivation are

Soil depth : It should be more than 75 cm

Shallow or compact soil: Poor root development and spread. Roots develop only on upper horizons and it rarely goes deeper than 30 cm.

Deep and permeable soil (>75 cm): Well developed tap root system, and rhizosphere occupy considerable soil volume.

Soil P^H: Slightly acidic to neutral pH is preferred (PH of 4.50 to 6.00 and even upto 7.00)

Table: Soil and climatic requirement for coffee

SL. No.	Climatic Factors	Arabica coffee	Robusta coffee
1	Soils	Deep, friable, rich in organic matter, well-drained and slightly acidic P^H (P^H of 6 to 6.50)	Same as in arabica
2	Extent of Slope	Gentle to moderate slope is ideal	Gentle slope to fairly level fields to be preferred
3	Aspect	North/East/North-Eastern aspects are ideal	North/East/North-Eastern aspects are ideal
4	Elevation for better growth and yield (m)	1000 to 1500m	500 to 1000m
5	Temperature	15 °C to 25 °C, cool equable	20°C to 30 °C, hot, humid
6	Relative humidity	70 to80 %	80 ot 90 %
7	Annual rainfall	1600 mm to 2500 mm	1000 to 2000 mm
8	Blossom showers (25 to 40 mm)	March – April	February – March
9	Backing showers (50-75 mm)	April – May	March – April

Varieties

1. S. 795 (robusta) – derivative of cross between S.288 “ kents”. Bushes tall, very vigorous, wide spreading and profuse growth. Yield is 2000kg/ha
2. Sln. 5A (robusta) – spontaneous robusta * arabica hybrid. Shows vigorous vegetative growth with thick small oblong and leathery leaves. Yield is 1200kg/ha
3. Cauvery Coffee (Selection –12)- Cauvery hybrid is a F4 Cross between Caturra (A semi dwarf variety of arabica) X Hybrid de Timor (A semi-dwarf hybrid) . Suitable for High Density planting
4. Chandragiri coffee: It is a newly released coffee in 2007-08 by Coffee Board with the original source from Portugal It was introduced in the year 1975 to CCRI Balehonnur from Portugal. Farm trials and intensive research trials were taken up at CCRI Balehonnur.

PROPAGATION

- Seed propagation and Vegetative propagation

A) Seed propagation

Preparation of seeds

- Selection of berries: Only ripe berries are marked from marked coffee trees for seed collection and remove pulp and get beans.
- Discard floats and defective beans
- Seed treatment: Treat seeds with fungicide and dry seeds under shade.

B) Vegetative propagation:

1)Cuttings and 2) Grafting

Propagation by cuttings:

- **Selection of shoots**: Select orthotropic (vertical shoots) suckers from elite trees.
- **Age of shoot**: Semihard wood and of about six months old. (3 to 6 months old shoots are better)

COFFEE PLANTING

- Planting
  - Slightly acid (pH 5.2 to 6.3) well drained soil
  - Beginning of wet season
  - Vertical position or 30° angle
- Spacing - need light for fruit ripening
  - Arabica, 1350 trees/ha
  - Robusta, 900-1000 trees/ha
- Time to fruiting
  - Take 3-4 years to obtain mature plant
  - Fruit on year old wood

Planting and aftercare

- **Site selection:**

The selected site should have following provisions;

- Water supply : As perennial source
- Soil rich in organic matter (humus)
- Gentle Slope : Slope towards N or NE or E direction
- Drainage : Provision should be there for adequate drainage
- Altitude: Minimum of 500 m asl (Arabica 1000 m to 1500m while robusta 500 m to 1000m asl)
- Wind break: Eastern wind during December- February causes injury to plants (cold injury). Hence, wind belts of silver oak or orange or tree coffee should be raised
- Partial shade: Clear natural vegetation for providing required partial shade to coffee growth. It can be done by selective felling /retention of desired species of wild shade trees in the natural forest vegetation.

Spacing and planting:
Spacing

Sl. No	Type of Coffee (species)	Variety	Spacing
1	Arabica	Talls	6’ x 6’ or 7’ x 6’ or 7’ x 7’
2	Arabica	Dwarfs (Cauvery / Sanramon)	5’ x 5’
3	Robusta	Talls (S-274 and old robustas) S-1 R and S-2 R	10’ x10’ or 12’ x 12’
4	Robusta	C x R (S-3R)	8’ x 8’
		Other robustas viz., Old robusta and S-274	10’ x10’ or 12’ x 12’

Plane land = square system of planting

sloppy lands =Contour planting

Steep slopes = Terrace planting

Opening up of pits

- **Time**: March-April (Immediately after the first few summer showers to give scope for weathering for about a month (at least 15 to 20 days))
- **Size of pit:** Depending on soil depth /type

  45 cm x 45 cm x 45 cm (LBD) - Always leave 15 –20 days for weathering.

Germinating Coffee Seeds

Coffee Seedlings

Shade and Coffee Production

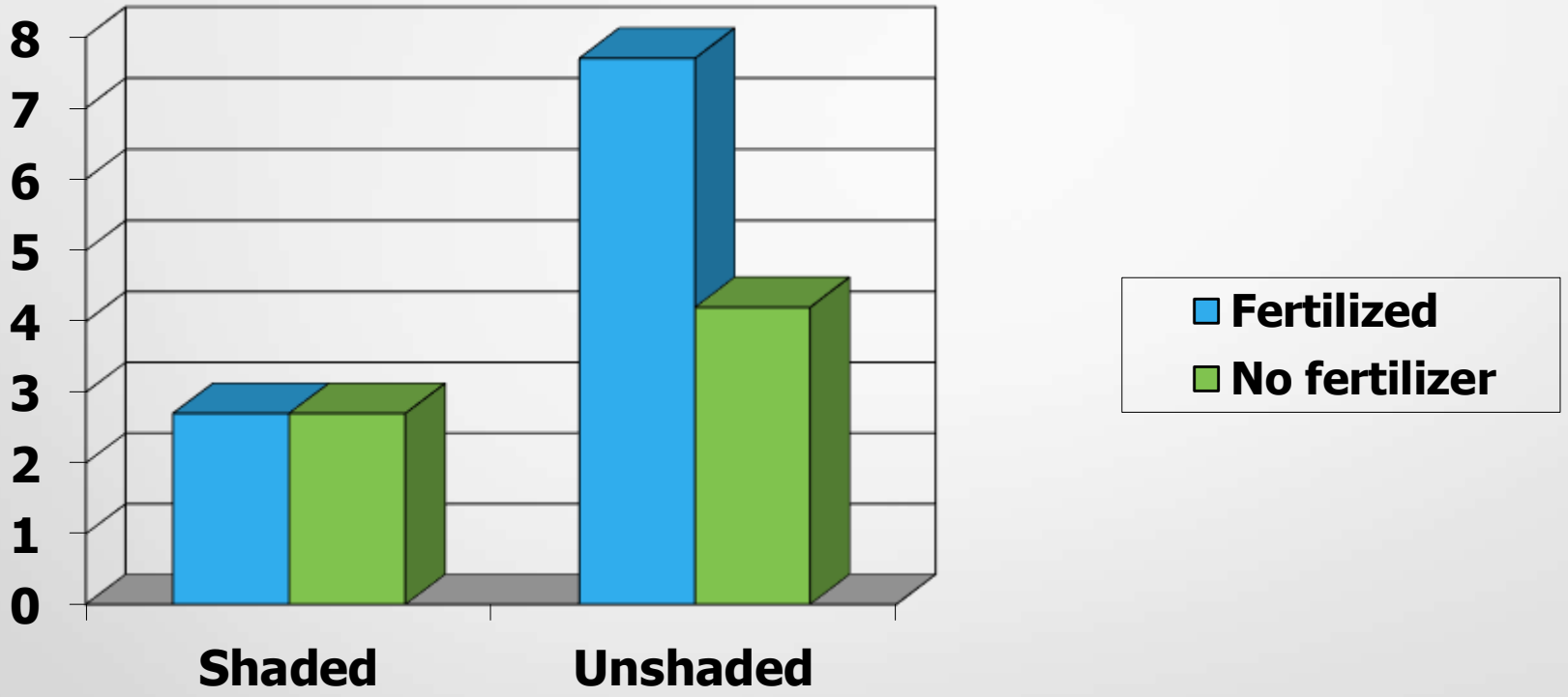
- Both species are understorey trees
  - Well adapted to shade
  - Initially coffee was planted under shade
  - Small holders may use mixed farming

- Later unshaded plants were shown to produce higher yields

Shade management

- **Beneficial effects of shade in coffee**
  - **Quality improvement**: Shade trees form natural canopy and it improves aromatic properties.
  - **Improved foliar health**: Shade helps in getting glassy elegant leaves and controls pre mature yellowing of leaves, defoliation and dieback.
  - **Mulching effect:** Leaves shed from the shade trees acts as soil mulch which in turn held in conserving the soil moisture and prevents soil erosion and improves soil organic matter status.
  - **Temperature regulation:** Insulation effect leading to buffering effect in soil temperature.
  - **Improved organic matter status of soil :** Decomposed leafy materials improves organic matter content of soil. There will be minimum loss of humus under shade thereby improving soil physical conditions.
  - **Disease incidence :** some of the diseases viz., *Cercospora* leaf spot and *Colletotrichum* etc are minimized under shaded situations
  - **Yield regulations:** Shaded situations prevents over bearing in any of the particular year and results in less variations / fluctuations in annual yields.

Shade and Coffee Production



Conclusion:

High input system - better with fertilizer

Low input system - not as essential

Training and Pruning

- **Training/Pruning objectives**
  - **Maximize # plagiotrophic stems (fruiting wood)**
  - **Shape trees**
    - **Maximize use of space**
    - **Ease of management**
  - **Maintain open tree to allow good light penetration**
  - **Minimize biennial bearing**
  - **Remove diseased and dead wood**

Types of training

1)**Single stem training**: Suitable under India conditions.

2)**Multiple stem**: Practiced in American and Latin American countries.

- **1) Single stem system:**

- **Topping of growing main-stem**
- Purpose of topping/capping:
- 1) To restrict vertical growth and facilitating lateral branching giving increased fruiting area.
- 2) Thickening of main stem: It also helps in diversion of food material to thicken the main stem and primary branches.
- As soon as the plant reaches a desirable height (first topping height) the growth of bush is restricted by topping/capping.

Raising of second tier:

- Depending on the fertility of the soil and spreading of the plant when plants attain about 4.50 to 5 ft height (135 to 150 cm) the second tier is raised.

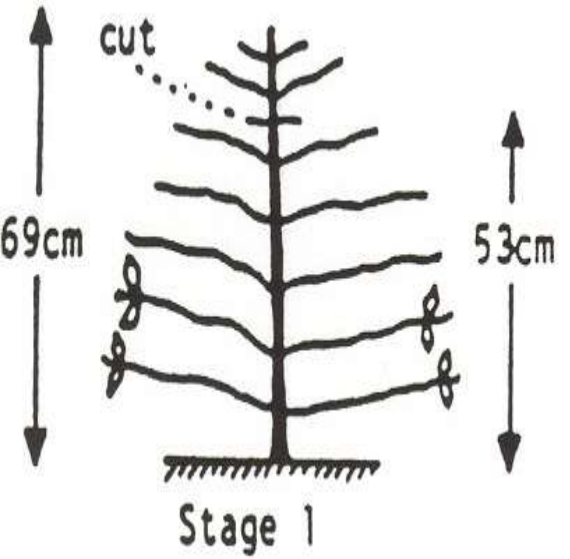
Table: First topping height in coffee

Sl. No.	Variety	Topping height I - Tire (cm)	Remarks	II Tier height
1	Arabica Tall	60 to 75 (2.5 feet)	In about 9-12 months stage after planting	4.50 to 5 ft
2	Arabica Dwarfs	90 to 135 (3 to 4.5 ft.)		
3	Robusta	105 to 120 cm (3.50 to 4 ft)	In about 18-24 months stage	4.50 to 5.00 ft

Single Stem Training
(Central leader)

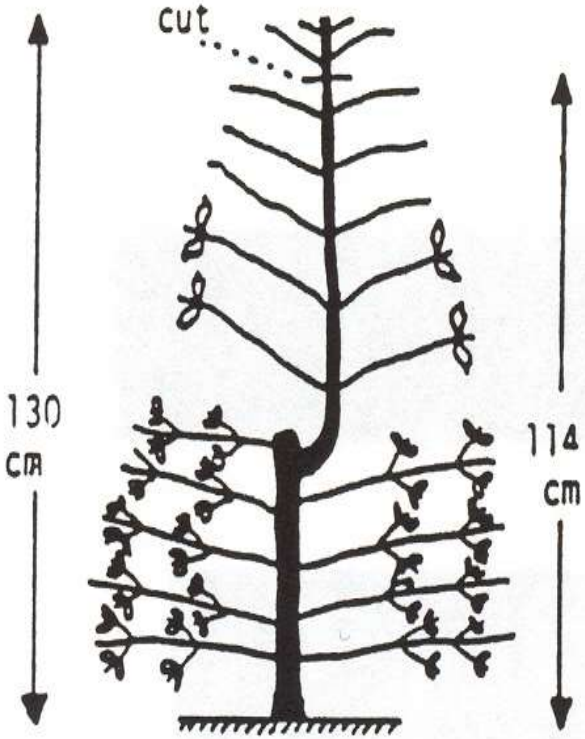
- **Cut back orthotropic stem**
  - Encourages plagiotropic stem formation
  - Select one orthotropic as new leader
- **Repeat for 3-5 years**
  - With each cycle the tree gets bigger
  - Lower limbs die due to lack of light
- **Rejuvenate after 3-5 years**
  - To reduce size of tree
  - Cut back to 40-50 cm height

Single Stem Training
(Central leader)



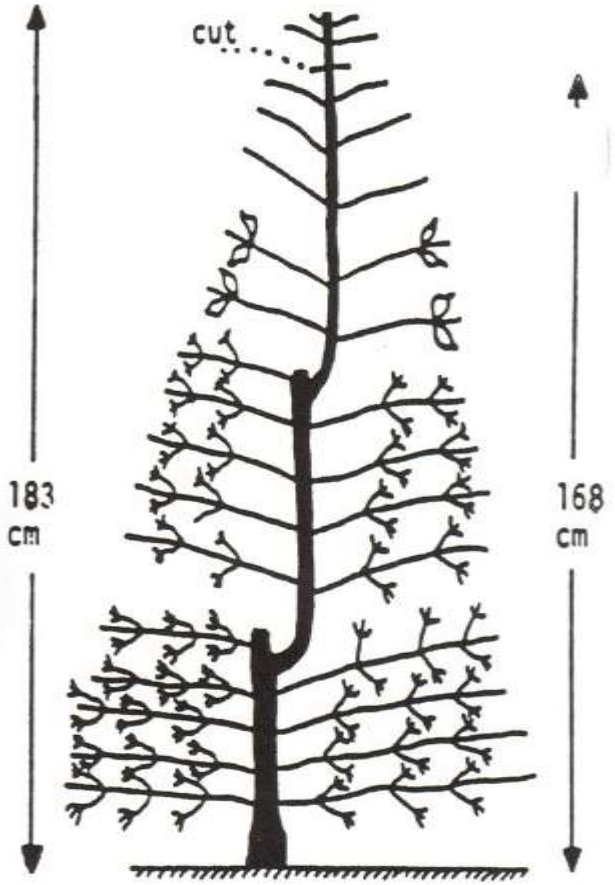
Stage 1

When tree reaches a height of 69cm, cap at 53cm.



Stage 2

One sucker allowed to develop from below first capping. When it attains height of 130cm cap back to 114cm.



Stage 3

One sucker allowed to develop from below second capping. When it attains height of 183cm cap back to 168cm.

2) Multiple stem system (Agobiada system)

- **Countries**: Practiced in African and Latin American countries. Here multiple stems are encouraged by bending the main stem (i.e., Agobiada system
- In India multiple stem training system is practiced under certain circumstances *viz.,*

Replanted fields: When old blocks are to be replanted with a new material, the old plants are stumped and converted into multiple stem to yield crops until the new plants come to bearing.

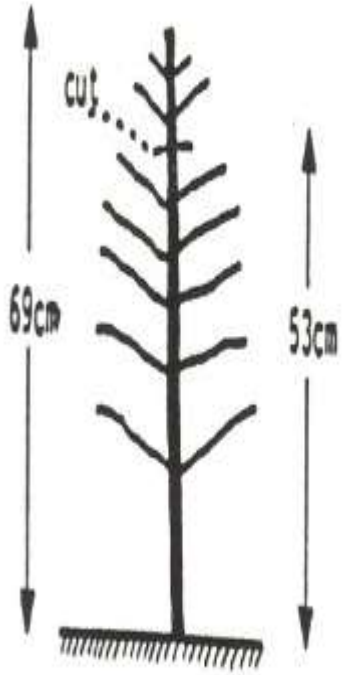
High density planting: Here coffee is planted very closely in the initial years and later thinned out to normal spacing.

- Here the plants which are to be thinned out (removed or going plants) are raised on multiple stems for enabling the main plants to spread out their laterals.

2) Multiple Stem Training (Modified Central Leader)

- Leave 2-8 orthotropic stems
- Pruning
  - Cut out wood in center
  - Continues growing taller
  - Cropping area moves higher
- Rejuvenation every 4-6 years
  - Need to lower fruiting surface
  - Allow basal suckers to grow

Multiple Stem Training
(Modified Central Leader)

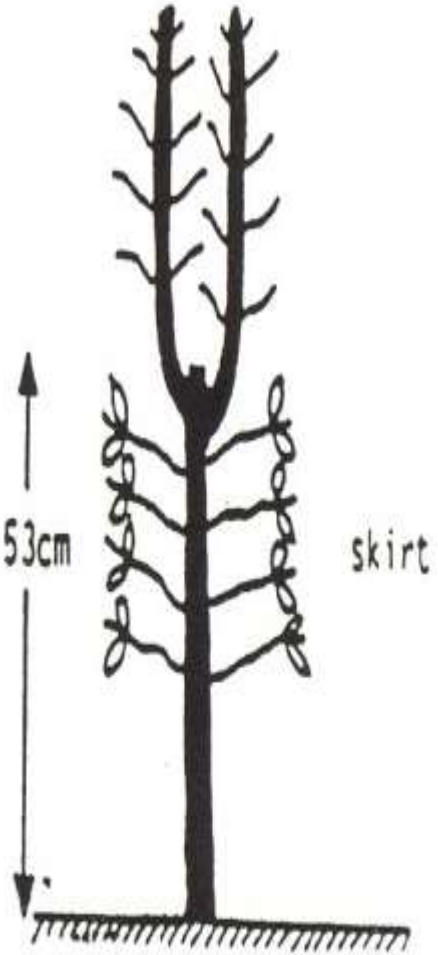


Stage 1

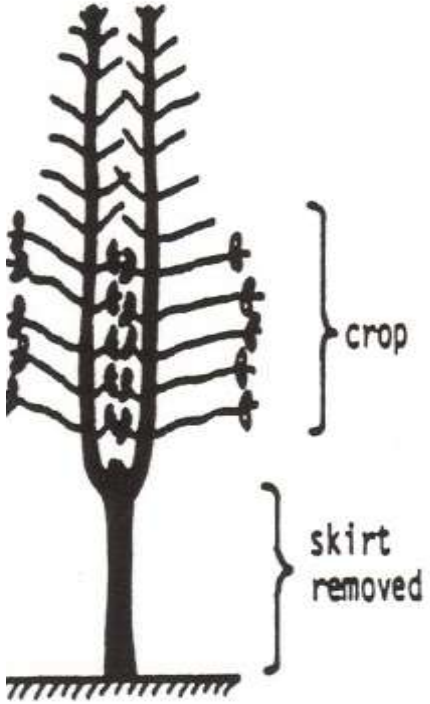
When tree reaches a height of 69cm, cap at 53cm.

Stage 1 (a)

Details of sucker growth and removal of branches immediately above them



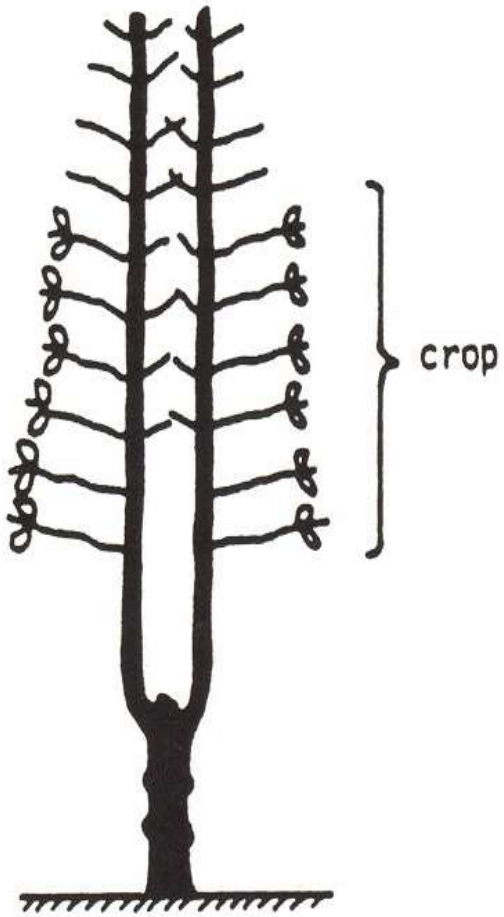
Stage 2



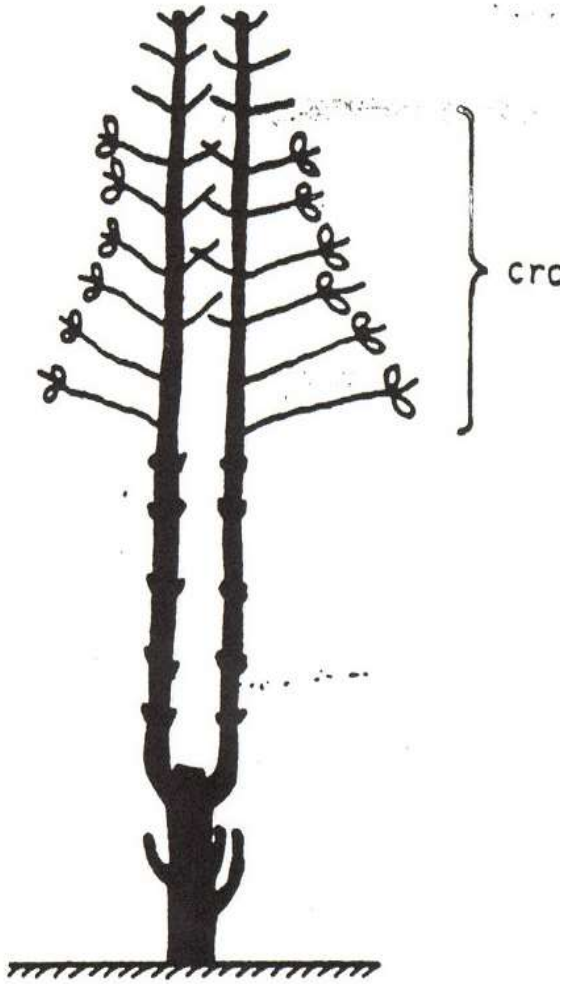
Stage 3

rther development
two stems; skirt
moved and crop on
wer branches

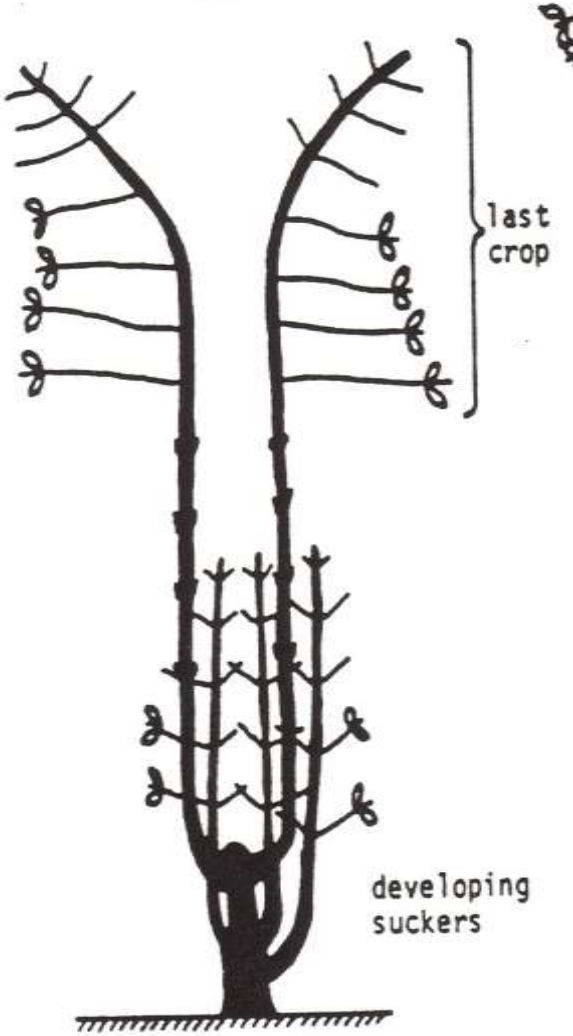
Multiple Stem Training
(Modified Central Leader)



Stage 4
The optimum bearing stage



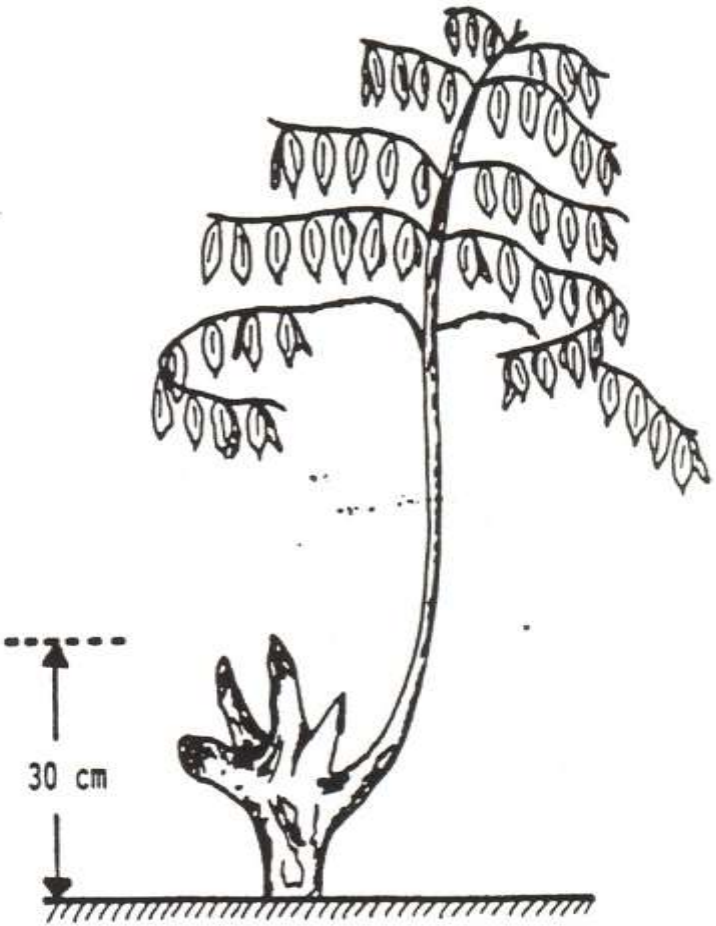
Stage 5
The optimum bearing stage

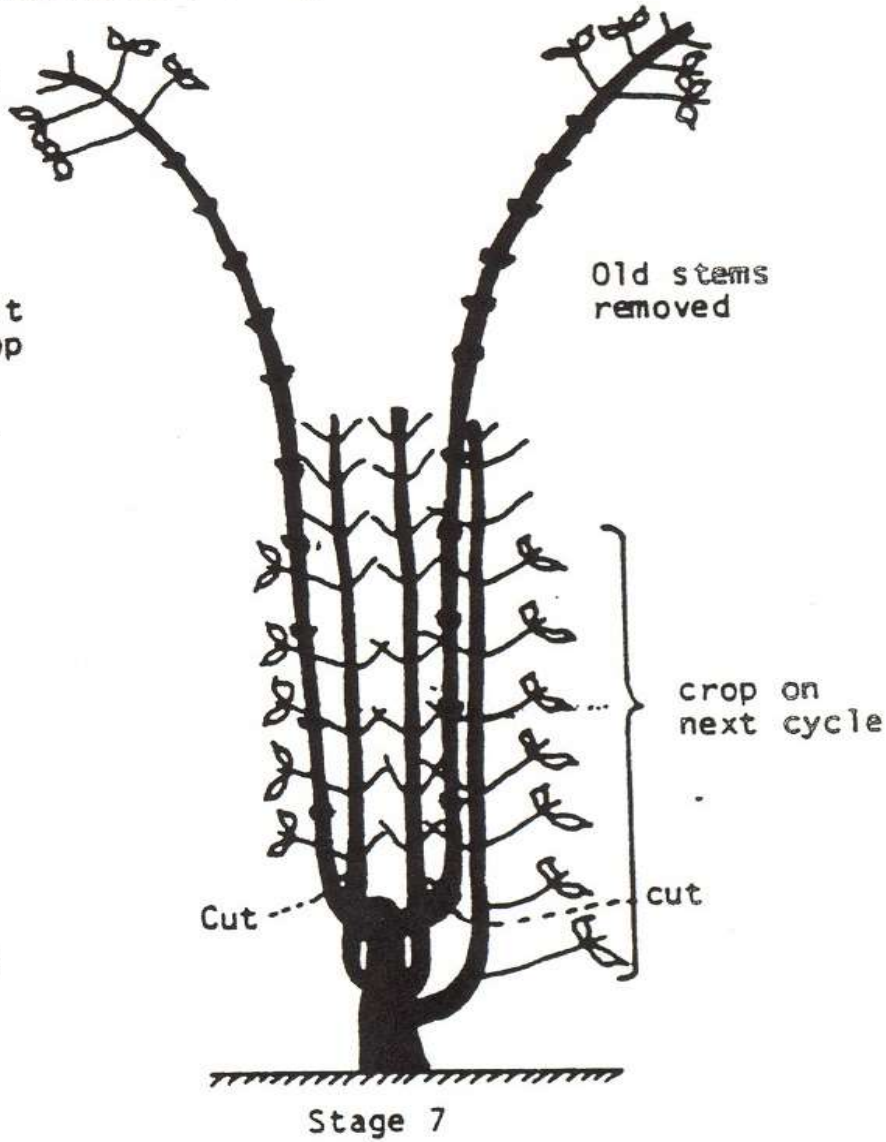


Stage 6

Multiple Stem Training
(Modified Central Leader)

Figure 7.12: Multiple-stem Pruning: Stumping Leaving a Lung: Ideal





Pruning in Coffee

Benefits of pruning in coffee:

- **Yield regulation** : Pruning reduces the risk of overbearing in any of the particular year.
- **Pest and disease incidence** : By pruning there will be better entry of sunlight and air in to the bushes there by minimizing the incidence of pests and diseases.
- **Manageable shape** : By proper pruning the tree is maintained in a manageable shape thereby improving the efficiency of field operations *viz., spraying, swabbing, harvesting etc*

Methods Of Pruning

1) Light pruning:

- **Time of pruning:** Starts after the harvest of coffee (December to February) and continues till the onset of monsoon. However, it is better to prune after few summer showers.

Parts pruned during light pruning in coffee:

- 1) Old branches
- 2) Unproductive branches
- 3) Criss-cross branches
- 4) Dead and broaken/damaged branches
- 7) Disease and pest affected parts
- 8) Suckers

II) Medium to severe pruning:

✓ **Periodicity of medium to severe pruning: It is done once in four years usually to replace the laterals.**

Manuring in coffee

Nutrition Management

- Maintaining optimum pH by liming is essential requirement for nutrition management in coffee. If proper pH is not maintained, the applied fertilizers will not be utilised by the plants effectively.
- Soil testing at least once in 2-3 years should be mandatory for lime and fertilizer applications.
- Use **agricultural lime analysing 80% calcium carbonate**. November is the best period for lime application. Application of dolomite lime once in a while in rotation is beneficial.
- Application of bulky organic manures like **FYM or compost @ 5 tonnes/ha** once in two years would improve the soil condition and better utilization of applied fertilizers.
- The recommended dose of **fertilizers should be applied in three splits** (post-blossom, pre-monsoon, post-monsoon) by adopting drip circle method.

Fertilizer recommendation in coffee

Age of plant	(Dose per plant in grams) Pre blossom (March)			Post blossom (May)			Post Monsoon (October)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
I Year	8	5	8	8	5	8	8	5	8
II & III Year	10	8	10	10	8	10	10	8	10
IV Year	13	10	13	13	10	13	13	10	13
V Year & Onwards	24	15	24	24	15	24	24	15	24

HARVESTING AND YIELD

Hastening fruit ripening in coffee:

Purpose: Speedy and uniform ripening will give scope for quick and early harvest = reduced cost of harvesting in coffee.

Harvesting the berries:

In India there is only one cropping season. Arabica coffee harvested from November to January and Robusta coffee from December to February. The crop will be ready for the first harvest in about 3 - 4 years but economic yields are obtained from 5 - 12 years onwards upto 50 years. The berries are harvested when they turn red to deep crimson colour. Season of harvest is from October to February. Harvesting is done in stages as follows;

HARVEST

- Most done by hand
  - Ripe berries only
    - Pick every 8-10 days
  - In Brazil, allow cherries to dry on tree
- Machine harvest in Brazil

- Fly picking: Small scale picking of ripe berries from October - November to February.
- Main picking: Well formed ripe berries are harvested in December.
- Stripping: All left over berries irrespective of ripening are harvested after main picking.
- Gleanings: Collection of fruits that have dropped down during harvesting.

COFFEE PROCESSING

Bean Processing done on the Farm

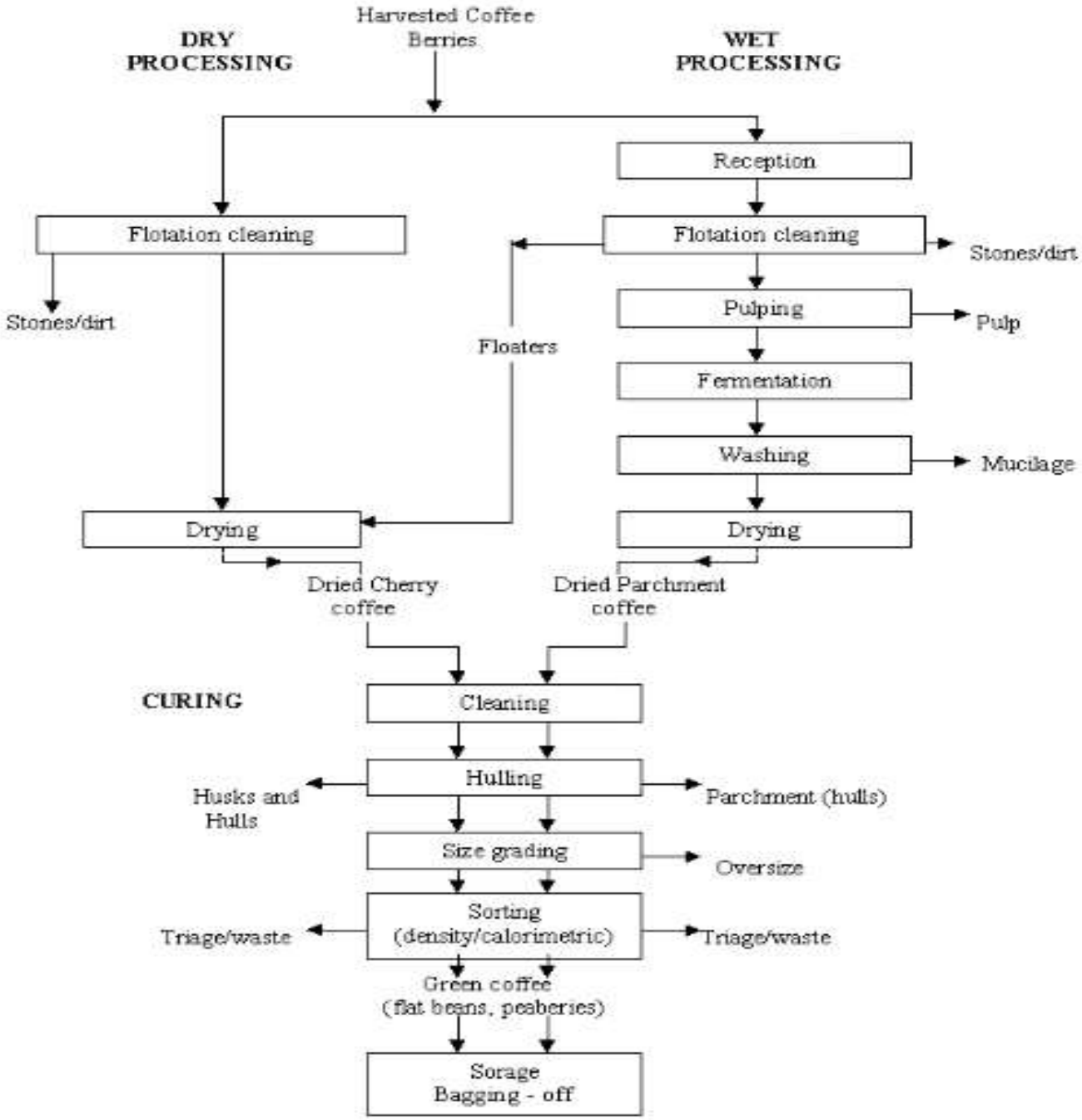


Fig. 2. Flow sheet illustrating the stages of wet and dry processing of coffee

Wet Method

- Start on Harvest Day
  - Separate trash and defective berries by flotation
  - Good berries are depulped same day
- Fermentation
  - Only to remove mucilaginous covering
  - Excessive heat destroys flavor

Wet Method

- **Washed**
  - Water under pressure
- **Dried - spread out to dry**
  - Sun
  - Artificial heat
- **Best quality**
  - Gives coffee that is cleaner, brighter, fruitier, better acidity

Dry Method (Natural Method) (Most traditional and least expensive)

- **Drying (Indonesia, Ethiopia, Brazil, Yemen)**
  - Initial drying done on trees
  - Spread on concrete, tile or matted surfac
    - 2” thick and constantly raked
    - 3-15 days until specific moisture

Dry Method
(Most traditional and least expensive)

- Remove pericarp
  - Mortar and pestle or machine
- Chaff removed via winnowing and picking
- Sorted by size, shape, density and color
- Packed in 60 kg bags for processing

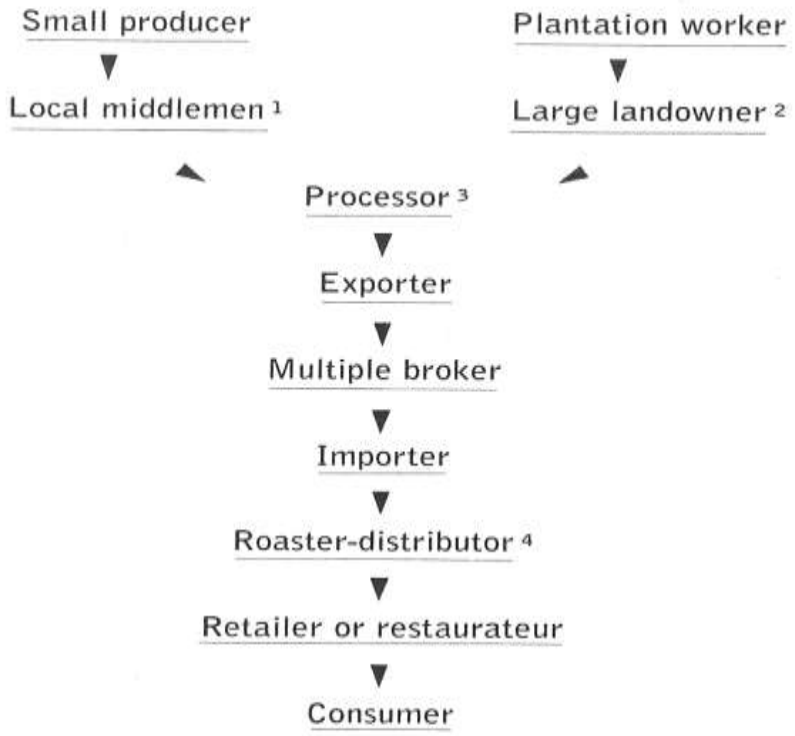
Industrial Processing
(Usually by importing company)

- **Grading process**
  - Redry and clean the parchment beans before using
  - Remove testa (hulling and polishing)
  - Sort on size and density
- **Roasting (370°F to 540°F)**
  - Removes moisture
    - Light roast lose 3-5% moisture
    - Dark roast lose 8-14% moisture
  - Time (up to 30 min) determines flavor

Industrial Processing
(Usually by importing company)

- Caffeine Reduction
  - Add water to beans
  - Extract with
    - Methylene chloride and ethyl acetate
    - Residual solvent removed via low level steam drying
  - Caffeine can be recovered with water extraction of organic solvent

The Conventional Coffee Path
From coffee tree to cup



1. There can be more than one level of intermediary trader.
2. Large landowners most often have their own processing plants.
3. Coffee must be shelled and classified prior to export. Some coffee processors export directly, others are linked to multinational corporations in importing countries.
4. Typically, coffee companies roast, package and market their coffee.

Distribution of Coffee