IMPORTANCE AND CULTIVATION TECHNOLOGY OF SPICES

Spices : Ginger, Turmeric, Cardamom, Pepper, Coriander, Cumin, Fenugreek

Aromatic Crops : Lemon grass, Citronella, Palmarosa, Vettiver, Geranium, Dawana

Medicinal Plants : Diascorea, Rauwolfia, Belladona, Nuxvomica, Ocimum, Periwinkle, Aloa, Gugul, Nux vomica, Solanum khasiamum, Aonla,Senna, Stevia,Plantago, Coleus, Acorus, Aswagandha.

Plantation Crops : Coconut, Arecanut, Betelvine, Cashew nut, Cocoa, Coffee, Oil palm.

REFERENCES :

Spices and Condiments	-	J.S.Pruthi
Spices and Plantation Crops	-	Shanmugavelu & Madhav Rao
Coconut	-	Thompan
Tropical fruits	-	Bhose & Mitra
Cashew	-	Nayar et. al.
Oil palm Production Technology	-	Nayar & Nambuter

SPICE : It is the product used as food adjutant which add aroma and flavour to the food.

CONDIMENT : It is the product used as food adjutant which add taste to the food.

In case of both, it is the natural plant product, vegetable product corn mixture used in whole corn ground farm for imputing flavour, aroma, and pungency to the food and also seasoning of the food.

Ex : Cardamom, Cinnamon, Pepper.

MEDICINAL PLANT : It is any plant pact corn product, seed, back, leaves, root, flower, fruit derived from these parts are used in different systems of medicines like Allopath, Ayurved, Homoeopathy and Siddha. These are used for curative properties to cure Heymans.

ISMH : Indian System of Medicines & Homoeopathy

AYUSH : Ayurved, Yoga, Unani, Siddha & Homoeopathy

Aromatic plants : Ex : Sandalwood, Dawana, Rose.

These are the plants which contain aromatic essential oils and are extracted for perfumery, cosmetic, flavouring, medicinal and also other human uses.

PLANTATION CROPS : These are the plants where the products are used after processing. Ex : Arecanut, Cocoa.

Classification:

BASED ON FAMILY :

Ex :

Piperaceae	-	Pepper
Umbelliferae	-	Fennel, Coriander, Cumin and Caraway.
Zingiberaceae	-	Turmeric, Ginger
Solanaceae	-	Capsicum, Chilli
Leguminaceae	-	Fenugreek, Tamarind
Liliaceae	-	Onion

BASED ON LONGIVITY :

1. Annual spices : Coriander, Mint, Menthi
2. Biennial spices : Onion, Garlic
3. Perennial spices : Clove, Nutmeg, Pepper

BASED ON THE TYPE OF PLANT :

1. Tree spices : Clove, nutmeg, Cinnamon, Cassia
2. Bush spices : Cardamom
3. Herbaceous spices : Coriander, Fenugreek, Fennel, Cumin
4. Climber spices : Pepper, Vanilla

BASED ON ORIGIN & FLAVOUR:

1. Pungent spices : Pepper, Ginger, Chilli, Mustard
2. Aromatic fruits : Cardamom, Nutmeg, Fenugreek, Dill, Cumin, Coriander
3. Aromatic back : Cinnamon, Cassia
4. Phenolic spices : Clove, Allspice
5. Coloured spices : Turmeric, Saffron

BASED ON ACTIVE PRINCIPLE (ALKALOID) :

1. Ajonean – Thymol
2. Black pepper – Piperine, Piperidine
3. Cumin seed – Essential oil (Cuminaldehyde)
4. Chilli/Capsicum – Capsaicin, Oleoresin
5. Coriander – Essential oil (Coriandeol)
6. Garlic – Allicin
7. Ginger – Gingerol, Gingerone
8. Turmeric – Curcumin

PLANT PART/S USED AS SPICE :

1. Mace – Aril
2. Bark – Cassia, Cinnamon
3. Berries – Black pepper, All spice
4. Buds – Clove
5. Bulbs – Onion, Garlic
6. Floral parts – Saffron
7. Fruits : Capsule – Capsicum, Chilli, Cardamom, Berries – Pepper, All spice
8. Kernel : Nutmeg
9. Leaves – Mint, Peppermint, curry leaf
10. Beans/pods – Tamarind, Vanilla
11. Rhizome – Ginger, Turmeric
12. Roots – Angelica, Horse radish
13. Seeds – Fennel, Fenugreek, Ajowan, caraway, Cumin, Dill

In India in the year 2003-04. 2.44 lakh tones of spices and condiments (6.3%) were produced.

And in the year 2004-05. 2.41 lakh tones valued to 415 million dollars

In India, 2005; Total spices cultivated in the area is 2.4 m ha and 3.2 million tones of production.

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Black pepper

S.name : Piper nigrum

Family : Piperaceae

Origin : Western Ghats (Malabar)

Edible plant Part : Berry (fruit)

Popularly known as king of spices

- Dried mature fruit of evergreen climbing woody vine
- Valued for aroma, hot, pungent biting taste
- Used for flavouring and seasoning
- Most valuable and important foreign exchange earner
- 50% of spices foreign exchange
- Referred as “king of spices” and “Black Gold”
- India is major producer and exporting country
- Southern states – Kerala, Karnataka, Tamilnadu and Pondicherry

Important uses

- Pungent principle – **Piperine**, economic part is **Berry- Kalimirchi.**
- Good medicinal properties, Main use culinary
- Flavouring of processed food material
- Processing of meat
- Berries in pickles preservative
- Aroma and pungency
- Aroma – essential oils
- Pungency – oleoresins
- Piperine- stimulates flow of saliva and gastric juices – cooling effect.
- Flavouring sauces, soups, beverages, liquors
- In India important medicine- control of cough, cold, malaria,

Botany

- Perennial evergreen woody climber – 10 m height
- Extensive but shallow root system
- Vines – branches horizontally from nodes – do not grow longer
- Branches are

Five distinctive type of stem portions

1. Main stem: Originate from seed or stem cutting

2. Runner shoots: Produced basal portion of main stem, right angle to main stem restricted 50 cm from ground.
3. Fruiting branches(Plagiotropes)
   Produced from nodes, right angle to main stem , grow laterally, bearing spikes.

4. Top shoots (Orthotropes)
   After vertical completion of vertical growth-The shoots that are produced at the Top portion of the main shoot are called Top shoots and they give bushy appearance-They have shorter and thicker internodes- Profuse branching- Large number of adventitious roots.

5. Hanging shoots (Geotropes)
   Fully grown vine- Top plagiotropes- special type of shoots- hang down and grow geotropically.

- ✓ Inflorescence is spike (pendent spike) – opposite to leaves – Plageotropic 5-15 cm long 50-150 minute flowers
- ✓ Vines either unisexual with monoecious or dioecious or hermaphrodites (bisexual)
- ✓ Classified as male, female or hermaphrodite
- ✓ Cultivated types are bisexuals only
- ✓ Male flowers few (1-20%)
- ✓ High yielding types – 70-98% bisexual flowers in each spike
- ✓ Self and cross pollination – more crosspollination
- ✓ Fruit is single seeded berry, globose or oval
- ✓ Thin pericarp around seed
- ✓ Each spike 50-60 fruits
- ✓ Exocarp turns green to red on ripening and black on drying

Propagation

- ✓ Vegetative
- ✓ Variation in seedling progenies – seedlings mostly dioecious and late bearing (7-8 years)
- ✓ Usual method of vegetative propagation cuttings from runner shoots – elite mother vines
- ✓ Selection of mother vine
  1. Suitable for locality
  2. System of cultivation
  3. High yielder, high bisexual flowers
- ✓ Runner shoots from basal portion coiled on wooden pegs fixed at base of vine to prevent shoots coming in contact with soil and striking roots

- ✓ Runner shoots separated – February – March – made into 2 to 3 node cuttings after removing leaves
- ✓ Cuttings planted vertically in nursery beds or containers – one node buried in soil
- ✓ Sufficient shade and watering provided
- ✓ Cuttings ready in May-June

Rapid multiplication method

- IISR developed method to multiply plants
- Rapidly
- Replanting of senile, poor yielding vines
- Improved varieties need large scale multiplication
- Pepper vines (runner and terminal shoots) grown over rooting medium filled in bamboo split piece.
- As vine grows, nodes get rooted, each node is separated and planted in individual bags.
- Trenches 40 cm wide, 60 cm deep filled with soil sand compost (5:1:1)
- Select bamboos 7-8 cm dia cut them 1.5 m long pieces split them to halves keeping septum
- Arrange the bamboos at 45 ^{o} angle
- Rooted cuttings planted in trench
- As vine grows fill bamboo split rooting mixture cow dung, coir dust and sand in Equal proportion
- Tie vine carefully to bamboo stick with banana fibre so every node should contact With rooting medium.
- Vine reach top of bamboo nip off the tip and crush at 3 or 4 th node from ground
- After 7 to 8 days cut the vine at crushes place and remove it from bamboo with roots intact with adhering soil
- Cut into single nodded cuttings and plant in poly sleeve bags.
- First cutting at three and three half months subsequent at two and two half months
- 10 cuttings in one harvest about 40 cuttings in year
- Multiplication rate of 1: 40

Seed

- Raised from seeds
- Fully ripened berries soaked in water over night and rubbed with paste of cow dung
- Sown in nursery
- Seeds germinate in one month ready for transplanting by 45 days.

- Transplanting is done July- August months.
- Practice to sow seeds with seed coat after drying for three days.
- Seeds viable up to 20 days after harvest.
- Progenies mixed characters, 7 to 8 years for bearing- Not recommended.

Varieties

- More than 70 varieties – difference is sexual composition of flowers
- Bisexual types selected – cultivation
  1. Karimunda: - Most popular variety of kerala bisexual – prolific and regular bearer – Good driage (35%) – good quality pepper – suitable for intercropping high density cropping.
  2. Kalluveli: - (Kallu vally) – North kerala – with stands water stress – tolerant to phytophthora wilt
  3. Kottanandan: - South kerala – bisexual – regular yields
  4. Blam kottah: - North kerala – very vigorous large leaves
  5. Varieties from Parniyur
  6. Varieties from IISR Calicut
  7. Improved varieties
  8. Improved varieties

Name	**Parentage**	**Yield /vine(Kg)**
Panniyur-1	F1 hybrid Uthirankotah x Cheriyakaniakadan	2.5
Panniyur-2 Krishna	Open pollinated seedlings of Balankottah	4.5
Panniyur-3 (Shima)	F1 hybrid Uthirankotah x Cheriyakaniakadan	4.4
Panniyur-4	Selection from Kuthravally II	2.3

Panniyur-5	O.P progeny of Perum kodi	2.75
Sreekara	Selection from Kanmundu (KS 14)	4.8
Subhakara	Selection from Kariamundu (KS27)	4.2
Panchami	Selecton from Aimpiriyan Coll . 856	5.2
Pournami	Selection from Ottaplackal Type coll.No.812	4.7

Climate

- Crop – humid tropics – adequate rainfall, humidity and warm conditions
- 20^0N and S latitudes – 1500 m above MSL – commercial cultivation closer to equator well distributed annual rainfall of 200 to 250 cm
- Tolerate temperature between 10 to 40^0C – optimum 20-35^0C
- Shade loving plant – too much shade affect flowering and fruiting
- Hot and humid – western and eastern Ideal

Soil

- ✓ Wide range – clay loam, red loam, sandy loam and lateritic soils
- ✓ P^H 4.5- 6.0 – Best in virgin soils rich in O.M
- ✓ Ideal - well drained, friable, alluvial, rich in humus, low acidity.

Selection of site

- ✓ Sloping terrain – light soils easy percolation of water
- ✓ Slopes north and north western preferred

Systems of cultivation

- ✓ Mono as well as mixed crop
- ✓ Three systems
  1. Cleaning jungles – large scale cultivation on hill slopes planting standards
  2. Mixed cropping – backyards – mango, jack, areca standards
  3. Intercrop – coffee, cardamom, mandarin orange

Establishment of the pepper garden

1. Planting of standard (supports)
2. Planting of pepper vines
3. Shade regulation

Planting of standard

- Need support for climbing
- Give support to pepper vine
- Raised 2-3 years prior to planting characters
- Straight, rough bark, quick growing, easily propagated, withstand pruning, deep root system
- **Silver oak – Erythrina indica**
- Planted at spacing of 3-4 m

Planting of Pepper vine

- Rooted cuttings 3 seedlings/standard
- June-July months
- Two nodes cuttings buried in soil
- Pure crop pits 30-50 cm cube are dug at 2.5 x2.5 m or 3 x 3m spacing 30 cm away from trunk on south side of trunk
- In coconut and Areca 100-120 cm away from trunk
- Watering and protection from direct sun and rain

Shade regulation

- Partial shade to be maintained
- Intense and thick shade effect flowering And fruiting
- Encourage Pollen flea beetle
- Regulated by lopping of branches
- Standard should be pruned to 6-8m

Shade is given hot weather to keep soil cool

Allow sunlight cool weather to encourage production of flowers and fruits.

In Kerala- shade regulated too much exposure to direct sun rays is prevented

During May - before rains branches of Erythrina standards- lopped off- to expose vines to sun to induce flowering and fruiting

Intense shade - pistillate flowers than hermaphrodite flowers- spikes sparse

Shade influences- sex of vine – ultimate production

Lopping of standards – fourth year onwards to shade vines optimally.

Excessive shading encourage pest problem.

Training and pruning

- Cuttings grow tied to standard using wire to give one main stem and two laterals
- Regularly pruned to give encourage lateral shoots
- Discourage bushy side growth
- First pruning 15-20cm from ground 8-9 nodes
- Second pruning when 9-10 nodes develop
- Vines pruned 7-9 times reach top nearly 3-4 m height
- Terminal growth is arrested by frequent pinching
- Lower portion is kept clean and unbranched at least one metre from ground level
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Manuring

Balanced amount of fertilizers
Same place for 20 to 25 years- depletion of nutrients
10 kg FYM + 100 g N + 40 g P2 O5 + 140 g K2O per standard for vine three years
Two split doses
April- May, August- September
First year- 1/3 of above dose
Second year- 2/3 of above dose
30 cm away from vine
Lime 500 g /plant

Harvesting and yield

Harvesting season spread over many months.
Pepper vines flower May-June
Harvesting – Plaines – Nov-Feb
Hills - Jan-Feb
Flowering – berry – 6 to 8 months
Vines commence bearing full crop from sixth year onwards
Full bearing vine – 1 kg of dry pepper
Economic yield up to 19 20 years

After 25 years replanting should be done
Yield 110-335 kg/year/ha of dry pepper

Processing

There are two main products 1. Black pepper 2 White pepper
In India – processed to Black pepper only limited to white pepper
Black pepper is used as directly spice oleoresin oil.
White pepper - dried and medicinal
Black pepper- fully developed unripe dried berries
Berries are separated from spike
Harvested berries sun dried until outer skin becomes tough black shrinks ans wrinkled
Drying – 10 – 15 % moisture
Recovery 26-36%
White pepper
Dried ripe fruit without pericarp
Prepared by removing the outer skin along with the pulp before drying
White pepper is also prepared by

1. Water steeping technique
2. Water steaming technique

Water steeping technique

It is a traditional and slow process
Includes

1) Steeping
2) De-pulping
3) Washing
4) Drying
5) Polishing

1. Steeping

- Spikes fully ripened filled in gunny bags
- Steeped in to water about 7-8 days.
- Skin gets loosened from seeds.

2. De pulping

- Pulp & Skin removed either by rubbing or trampling under feet

3. Washing

- De pulped seed washed & cleaned with fresh water done repeatedly

4. Drying

- Cleaned seed sun dried for 3-5 days on cement floor or mats till become white and moisture reduced to 10 to 15 %

5. Polishing

- Dried seed dull white.
- Further cleaned by rubbing another cloth
- Recovery is 25 %

Boiling and Steaming technique

- Improved/ advanced method
- Quick process developed by CFTRI, Mysore
- It involves

1) Boiling
2) De pulping
3) Blanching
4) Drying

1. Boiling

- Freshly harvested boiled for 15 minutes

2. De pulping

- Boiled berries de pulped using hand trampling under feet or mechanically

3. Bleaching

- De pulped seed washed with water then bleached with bleaching powder.

4. Drying

- Bleached berries sun dried for 2-3 days to moisture 10-15 %

CARDAMOM

(*Elittaria cardamomum*)

F*: Zingiberaceae*

Origin : Western ghats of south India, *i.e.,* Kerala

Cardomon is known as “Queen of the spices”.

Also known as “Green gold”.

One of the ancient spices and much valued.

Next to the black pepper in earning foreign exchange.

Economic part is capsule filled with tiny brown to black seeds.

There are 3 types of cardamom :

1. Small cardamom
2. Large cardamom
3. Bengal cardamom

Small/Malabar/Cyclone/True/Green/Lesser corn Choli, Elachi cardamom – *Elitteria cardamum*

Large/Greater Indian/Nepal cardamom cron, Badi elachi – *Amomum sabulatum*

Bengal/cardamom – *Amomum aromaticum*

Small cardamom :

It is more popular, occupying premium position, native to Kerala. Mostly grown in south India. Also grown in other countries like Thailand, Tanzania, Sri Lanka and Central America.

Large Cardamom : Native to Eastern Himalayas. Mainly grown in Darjeeling and Assam hills and Sikkim, other countries like Nepal, Bhutan, Indonesia and Laos.

Bengal Cardamom : Mainly grown in north Bengal and Kasi hills.

Uses of Cardamom :

1. It is used as flavouring material in 3 forms 1) Whole form, 2) Decorlicated seed, 3) Seed will be in ground form.

2. It is also used after distribution of essential oil and solvent extracted oleoresin.
3. In the international market, true cardamom is used as whole form (*C.masticatory*) and food flavorings.
4. Used for culinary purpose like spiced rice, tea, coffee, baked goods, sausage, soups, canned fish, sauce and flavouring of tobacco.
5. Essential oil is also used for flavouring of processing foods and liquids like cardials and liquors.
6. It is also used in perfume industries.
7. Oleo resins also have similar application of essential oils in flavouring of processed food used in sausage and meat products. Essential oil and oleo resins develop off- flavour when they exposed to air for prolonged periods.
8. it is used as a medicine. Used to combat digestive elements. Also used as aromatic and cardiac stimulants.
9. Chewed to prevent bad smell, indigestion
10. Checks sore throat and flu fever.

Area and Production :

India has largest area covering 90% or the world's area.

India is the largest producer, but now it is facing lot of tough competition from Guetimola to acquire top position in the world.

Mainly cultivated in southern states like Kerala – 60%, Tamil Nadu -10%, Karnataka – 30%.

Cardamom occupying second place in the spice market world next to black pepper.

Nearly 40% of the produce exported to other countries.

Botany : Small cardamom :

It is herbaceous, perennial in nature with underground rhizome. The aerial pseudo stem is made of leaf sheaths and plant attains nearly 2-3 m height dependin on the variety.

Leaves are lanceolate with short petioles. It is having shallow root systems. Flowers are born on racemose panicles which arrives directly from the raceme.

Panicles are upright in Mysore type and prosteate is Malabar type.

Flowers are small, sexual, pale white and fragrant with short pedicels.

Fruits are called as capsules, trilocular, sub lobose, rounded.

Seeds are 15-20 in number, dark brown or black when ripe. Seeds covered withwhite mucilage and seed coats.

Honey bees are the main pallinators and nearly in cardamom plantations. It requires 4-5 bee hives in 1 ha. it is a cross pollinated crop.

Climate : Small cardamom is a humid tropical plant.

In India, it is grown under natural conditions with ever green forest at an elevation of 600-1500 m above MSL. The optimum is 900-1200 m MSL, at this, gives good yields.

Prefers mean temperature of 10-35^{0}C and a well distributed rainfall of 1500 mm/anum.

Summer showers during February and April for flowering. It is highly sensitive to drought situations and strong winds. Also highly sensitive to sun scorching when it is given under open conditions. It gives very poor vegetative growth. It grows under shade. Provision of shade for cardamom provides micro climate i.e., good humidity and cool climatic conditions maintained.

Soils : Forest soils are rich in humus. Grows best in well drained, humus rich forest soils. Water logging and excess soil moisture is harmful. Moisture level should be of 40-50% of field capacity.

The ideal site for cardamom growing is sloping land with good drainage conditions. In India, it is grown in red, deep textured, lateritic forest soils.

Preparation of the land :

In forest area, under ground rhizomatous well developed root system should be removed. In case of excess shade, trees or branches should be thinned out. If shade plants are not available, the shade planting may be done before planting of the cardamom.

The selected site should be ploughed and leveled and pith of the size 40x40x30 cm or 60x60x30 cm. pith should be dig out depending on soil type of cardamom are grown.

Piths are dug out in April- May. Piths are field with mixture of top soil and compost spacing varies depending on the variety.

For Mysore type, spacing is 2-3x2-3 m

Malabar type, 2.2 m

It is propagated commercially by seeds.

Vegetative propagation is by side suckers.

Planting in the main field :

Best season for planting is May-June after receipt of monsoon showers.

Seedlings corn suckers planted in the pith upto collar region to encourage the plant growth. Cloudy days with light drizzling is best time for planting cardamom. We should also concentrate on the shade regulation.

Leaf fall should not coincide with flowering of cardamom. Cardamom is economically classified as Pseophyte (shade loving plants). Shade plants play role in healthy growth and bearing cardamom plants. It is grown luxuriously when grown under forest trees if plants are exposed to sun grown is effected, flowering and fruiting effected.

Provision of shade is important and necessary cultural practice in cardamom plantation.

Shade and shade regulation :

Artocarpus frazinifolius

Cedrella touna

Dirpyros ebenum

Mimorops elangi

Artocarpus heterophyllus

Advantages :

1. Regulates the soil moisture as well as temperature. It provides micro climate.
2. It protects cardamom from sun scorching and heavy rains.
3. Provides mulch material.
4. Prevents soil erosion through their root system.

Shade and Shade Regulations : In order to provide adequate light during monsoon, shade regulation may be taken up before one onset of monsoon.

A two tier canopy or a height not more than a 2 mt in between the lower and higher canopy is maintained optimum shade.

Intercultural operations :

Since cardamom is the surface feeder, the cardamom growing areas usually subjected to high rainfall. Hence the top soil is subjected to frequent leaching, which results in the loss of plant nutrients. There will be annual replacement through the incorporation of fallen leaves from the standard.

Manuring :

Manuring of plantation is very essential, which will increase the productivity of plantation.

Fertilizer dose of 30-60-30 kg /ha is applied twice in a year. In 2 equal doses. It should be applied at May-June as I-split helps in the production of suckers and development of capsules. II-split applied at September-October which helps in initiation of panicles.

Fertilizers should be applied 30 cm away from the base of the plant in a shallow trench 5-10 cm depth. This is recommended for Kerala region.

Irrigation : It is raised as rainfed crop. The yields of rainfed crop are low. Irrigation is given during day periods which will give more yields.

Most of the cardamom evergreen plants under undulations hence the conventional irrigation method is not useful. Mostly deep and sprinkler is preferable.

Weeding : During I year of planting, frequent weeding is done to eliminate the competition of young plants with needs. Depending on the intensity of crop 2-3 weeding are carried out.

I-needing is @ Aug – Sep. II- needing is @ Dec. Jan.

In case of sloppy lands slashing of the needs can be carried out, if not it may encourage the soil erosion. Weeds can also be controlled by weedicides like Paraquat @ 625 ml dissolved in 500 ml of water and sprayed in between the rows leaving 60 cm around the plant.

Mulching : Mulching is important operation in cardamom plantations. The fallen leaves under shade are utilized for mulching. It can be done in November-December which will reduce the drought situation by consuming the soil moisture.

Trashing/Cleaning : Removal of the old leaves and dry shoots at the plant base during the year. This cleaning is done once with the onset of monsoon rains under rainfed conditions under 2-3 times under irrigated conditions. Weeding and cleaning can be done together during May-June to promote the healthy growth of the new shoots. A final cleaning of old leaves can be done during which will prevents the damage of fruits by the rodents.

Raking/Digging : At the end of the monsoon rains elite raking can digging can be taken out around the plant upto a radius of 60-75 cm. this operation also helps to conserve the moisture during day period particularly in lone rainfall areas.

Earthing up : After the completion of monsoon, a thin layer of matter which is rich in dry matter at the base of plant upto the collar region which will encourage the new growth.

Cropping : Cardamom plants start bearing 2-3 years after planting. Flowering starts April – May and continue even upto August and September. Pak flowering season may be May-June. It takes 5-6 months from flowering to maturity. Always harvest only, ripe capsules at 25-30 days interval and harvesting can be completed in about 5-6 rounds. The peak period of harvesting is during October-November.

Harvesting indices : Pick the capsules before fully ripe, if fully ripe capsules are harvested, fruits will split out. The main harvest indices are there may be development of pale colour in fruits.

Yield : Yield varying depending on the age upto 10-12 years.

The economic crop can be obtained only IV or V year and it depends on age.

Harvesting in August, optimum yield is 50-70 kg of day capsule/ ha. There may be decline in the yields from 10-12th year. After that, a new plant can be taken up. The I-year bearing gives 20-25 kg/ha of day capsules.

I year - 20-25 kg/ha day capsule

II year - 50-70 kg/ha

III year - 90-100 kg/ha

After harvesting, the capsule can be used after the processing.

Processing :

Commercial product of cardamom is day capsule. At the time of harvesting, the capsules are juicy or fleshy. The capsules should be cared before sending to the market. This cured fruits can be send to drying, sorting and bleaching. After harvesting the capsules they can get dried in the sun or kiln drying.

The capsules can be sun dried upto 3-5 days. Sometimes, sun dried capsules can bleached and can stored. Curing of cardamom can be taken up artificially where drying will be completed. The green colour of capsules remains green.

In electrical drier, the capsules dried at a temperature of 45-50^{0}C for about 18 hours. In case of kiln drying, the capsules are dried over nigh temperature of 50-80^{0}C.

Green colour of the cardamom is important which fetch the higher price in the market.

The green cardamom is treated with alkali. It involves soaking of capsules in 2% washing soda solution for about 10 minutes and they ca be kept for drying.

To remove the foreign matter like stalks, petiole, the dried capsules rubbed with hands or with rough cloth and take later followed by winnowing.

The capsules can be sorted out according to size, colour and stored in black polythene bag or gunny bag to retain the green colour.

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GINGER

(*Zingiber officinalis*)

F : Zingiberaceae

Origin : South East Asia.

Economic part is rhizome, underground stem

Uses :

- Dry ginger is used directly as a spice

- Used for extraction of oils, oleoresins
- Used for the preparation of soft drinks, alcoholic beverages
- Also used for the preparation of pickles and confectionary
- The major use f the rare or green ginger in the culinary preparations
- The preserved ginger is used for both domestic, culinary purpose and also is processed foods
- It has several medicinal uses;

    Used incurring cough and cold

    Acts as good digestive stimulant

    Preparation of tea and coffee

    Used as …… and stimulant

Ginger commercially dried under ground stem portion. It is a herbaceous perennial plant and it is one of the 5 important major spices.

The dried rhizomes, seraped, peeled and prepared rhizomes having good aroma, flavour and pungency.

India is the largest producer of the dried ginger in the world accounting to > 60% of the world's production.

Among this production, almost 1/3rd being exported to the middle east countries. China is the competitor to our country. The other countries like Taiwan, Jamaica, Thailand, Mauritius, Australia and Nigeria growing ginger.

In India, Kerala is the largest producer which is contributing > 40% of India's production. The Kerala growing ginger is popularly known as 'Cochin Ginger'. The other states are Meghalaya, Orissa, West Bengal, Karnataka, Himachal Pradesh, Madhya Pradesh, Tamil Nadu, Gujarat and Andhra Pradesh. In A.P. ginger growing districts are Nellore, East Godavari, West Godavari, Medak, Visakhapatnam and Srikakulam.

Botany :

It is a herbaceous perennial plant. But it is grown as annual plant. It reaches to a height of 80-90 cm.

Leafy shoots having pseudostem, they are erect, having long leaf sheaths. Leaf lamina is very thin, linear, lanceolate, dark green above pale green beneath.

Ginger flowers rarely and the inflorescence is directly born on the rhizome portion. The underground stem portion is hard, thick, flattened, branched and covered with small scale like leaves and fibrous roots. Rhizome contains fibre and fibre content varies with the variety.

Propagation :

It is propagated through the rhizomes which are called as 'Seed rhizomes'. These preserved seed rhizomes ..... into the small pieces of 2.5-5 cm length called as 'Sets'. Weight of rhizome is 15-20 g, pieces having one or two buds. These buds are called as 'Eyes'.

Climate :

It grows best under warm humid climatic conditions. It is mainly cultivated under tropical situations at 1800 from MSL. It can grow better in irrigated and rainfed conditions. It requires moderate rainfall from sowing to sprouting, fairly heavy and well distributed rainfall during growing period. It requires some dry weather conditions for a temperature ranging between 28-35^{0}C for a month before harvesting. High humidity is required throughout the crop period. It can also thrive best under partial shade conditions. It is cultivated as an inter crop in coconut and arecanut ..... and mango, guava and grape orchards.

Soils :

Thrives well on vide range of soils. The soils with rich fertility and with well drained conditions are good. It is very sensitive to water logged conditions. A deep well drained, feasible humus rich soils are ideal soils. In India, grown in soils of sandy, clay loam, laterite and black soils.

Preparation of land :

For preparation of land, ploughing can be done for 5-8 times for through preparation of soil until the fine tilth is obtained. Preparation of land starts with the receipt of early summer showers in March.

Ginger can be raised by 2 systems

1. Bed system (rainfed conditions)
2. Ridge system (irrigated)

These two systems followed mainly depending on the rainfall and soil type.

For irrigated conditions, ridge method is followed. Ridges are made following the spacing of 40-45 cm with the height of 30 cm. the raised beds are prepared at a height of 15 cm with a width of 1 m and with a convenient length and inter space between the beds is 30-40 cm which act as irrigation channel as well as space for inter cultural operations.

In hilly slope area beds and ridges are formed according to contour lines.

Planting :

Season : Depending on the onset of rains, the season of planting varies from track to track, region to region. Seed rhizomes are planted during I-fort night of May in North India, mostly in Himachal Pradesh and I-fortnight of April in South India, in Kerala. In case of A.P., I-fortnight of May. Early planting is always beneficial which encourages god growth and able to withstand heavy rains during monsoon seasons. If planting is delayed yields will be reduced and there will be increase in the incidence of rhizome rot.

Seed rate : Seed rate ranges from 1500-1800 kg/ha. it varies depending on the region. In case of hilly areas, the seed rate may be 2500-3000 kg/ha. Seed set may be large in size 20-25 g.

Spacing : It varies depending on the region. Mostly, the spacing followed is 25-30 x 15-20 cm. the rhizomes can be planted at a depth of 4-5 cm, spacing followed is 45x15 cm.

Seed treatment : Seed rhizomes must be treated with 0.25% cerasan or 0.2% dithane M-45. the treatment must be given for 30 minutes for the control of soft rot diseases. Soil drenching also practiced with cerasan for sol borne diseases.

After seed treatment, they kept under shade and shifted into the gunny bags and kept for 2-5 days which will encourage the sprouting of eyes. After observation of plots, seed is planted n the field. Sprouting starts within a week after planting and continue upto 3 to 4 weeks.

Mulching :

Mulching in the field is very important operation in ginger cultivation. It has a number of advantages.

- Prevents the washing off of soils
- Conserves soil moisture
- Controls weed growth
- Improves physical properties of soil
- Mulch protects the sets and seed rhizomes and young sprouts from soils.
- Provides favourable conditions for sprouting of sets

Mulching can be done with green or dry leaves with FYM. It can be followed under rainfed and also under irrigated conditions. First mulching can be done at the time of planting. It requires 10-12 t/ha mulch. After I-mulching, *i.e*., after 40-60 days, II-mulching has t be done with 5 t/ha mulch simultaneously alongwith FYM (rainfed).

In case of integrated ginger crop, live mulching can be done by removing legume crops like conopea alongwith ginger.

This live mulches can be removed after 60 days of sowing. After removing, earthing up operation is taken up. This provides shade and conserve soil moisture and helps in better germination. Sometimes castor is also taken as a shade plant as well as wind break.

Irrigation :

Grows well in both rainfed and irrigated areas. In low rainfall are as under irrigation conditions, interval followed is 4-5 days depending on the situation soil type.

The recommendation is fortnight intervals (mid September) which will gives good development of rhizomes.

Manuring :

75-50-25 NPK kg/ha

This dosage should be applied in 3 splits dosages. FYM required is 25-30 t/ha.

Intercultural operations :

Weeding : 2-3 weedings can be required at early stages.

In ginger weeding is done to avoid the competition between growing ginger plants and needs to promote the growth of young sprouts. Usually 3-4 weedings are done between June to September should be done before fertilizer application and mulching.

After each weeding, soil must be earthing up in dose at the base of plants. Final earthing up is done at the end of September to ensure proper development of rhizome.

Harvesting :

Harvesting must be done depending on the purpose for whichit is harvested and also the time of harvesting and stage of maturity also depends on the purpose.

Ginger is mostly utilized as green ginger, dry ginger and pressured ginger.

Green ginger – Harvested 6 months after planting

Dry ginger – Harvested 6 months after planting

(The leaves turn yellow, start drying)

Pressured ginger – Harvested 7 months after planting, before they fully matured.

Rhizomes become more fibrous, more pungent. If delayed, these rhizomes are not suitable for preservation.

Before harvesting, light irrigation should be given. Rhizomes can be lifted by digging. After lifting, the top shoots and root portions of rhizome should be cut off. Then rhizomes are

soaked in water and then washed thoroughly 2-3 times with water to remove adhering soils. Then they shade dried for 1 to 2 days and then sent to the market as fresh or green ginger.

In Medak threshing of rhizomes is not practiced because to reduce the transpirational losses.

Yield :

10-15 t/ha - Rainfed sole crop

15-25 t/ha – Irrigated

Crop rotation :

Ginger is exhaustive crop hence it depletes nutrient in large quantities. Soil borne diseases will be increased if it grown continuously in same land. To avoid this, it can be rotated with other crops.

In irrigated lands, it can be rotated with beeline, banana, turmeric, onion, garlic, chillies and vegetables, field crops like sugarcane, maize, ragi and groundnut. In rainfed conditions, tapioca, yams, sweet potato, chilli which can be rotated with once in 3 years – 4 years.

Ginger an also be grown as intercrop in coconut, Arecanut, canapé, mango, guava and grape gardens.

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TURMERIC

(*Curcuma longa*)

F : Zingiberaceae

Curcuma amada (Mango ginger)

Curcuma aromatia, used in kumkum preparation

Origin : South East Asia.

Economic part used is rhizome.

Uses :

- A good spice used is a condiment
- Used as colouring agent
- Flavouring agent
- Antibiotic, antiseptic
- Traditional use
- Used in medicines
- Cosmetic preparations

Importance :

India is the largest producer of turmeric in the world after pepper, cardamom. Also grown in Bangladesh, China, Burma, Taiwan, Indonesia and Jamaica.

A.P. is leading in area and production which is accounting almost 50% of production. Other states growing turmeric are Tamil Nadu, Assam and Maharashtra. Export is major *i.e.,* 10-15% and maximum is utilized within the country. Turmeric ranks IV place in foreign exchange after pepper, cardamom and ginger.

Turmeric is growing in 5 agro-climatic zones in A.P.

1. Duggirala zone	-	Krishna, Guntur
2. Cuddpaha zone	-	Cuddapah and Kurnool
3. Nizambad zone	-	Nizamabad and Karimnagar
4. Godavari zone	-	East Godavari and West Godavari
5. Agency zone	-	Vizag and Srikakulam

Botany :

Herbaceous, perennial, tropical plant reaching to a height of 60-100 cm, grown as a annual plant. It has thick underground rhizomes and branched. Branches are known as fingers. Rhizomes are brown outward and bright orange inside. These rhizomes have a distinct smell and taste. Leaves are broad, lanceolate with long leaf stalk which enriches each other to form a psuedostem.

Propagation :

Propagated by rhizomes vegetatively. Both mother rhizomes and fingers are used for multiplication in general. …. mother rhizomes and 1^0 fingers are used as seed material. Mostly mother rhizomes used as planting material in Maharashtra, Kerala and Punjab. But n A.P., 1^0 fingers are used for planting.

Advantages :

Use of primary materials as seed, they keep better in storage and they are more tolerant to wet soil conditions, they give lower seed rate.

Climate : A tropical herb

Cultivated well from sea level to 1200 m. it requires warm and moist climate. Grows well under shady conditions. A rainfall of 100-200 cm/annum is sufficient.

Requires a temperature of 20-30^0C. but does not comes up well when temperature are < 10^0C

In 10 m rainfall areas, it can be grown as irrigated cropo and in heavy rainfall area, grown as rainfed crop.

Soils :

Soils ranging between black soils, sandy loam, red soils and black clay loams. Thrives best on soils with well drained conditions, loose and feasible soils which may be of rich sandy or clay loam soils. Very sensitive to water logging conditions.

Land preparation:

Land must be ploughed thoroughly until the soil become loose and friable. 4-6 deep ploughings must be taken tilth must be obtained at the depth of 20-25 cm. after ploughing, field in layed out into beds or less ridges and flowers depending on the growing conditions.

Systems of cultivation :

Depending up on the soil type and rainfall, there are two systems.

1. Bed system
2. Ridge and furrow method

1. Bed system : The beds of 1 m width and convenient length must be prepared following the spacing of 40-50 cm between the beds. It is mostly followed in heavy soils and heavy rainfall areas (Godavari zone).
2. Ridge and furrow method : Ridge of 25 cm ht must be prepared following spacing of 45-60 cm. it is mostly followed in low rainfall areas and practiced is Duggirala zone. In A.P., both the methods are in practice.

Planting season :

Planting season varied depending on the system of cultivation, varieties and region in A.P. and in Tamil Nadu planted during May-June or July-August. In Kerala and coastal regions and hilly areas, the seasons must be started with April because of early seasons.

In A.P., short duration variety like Kasturi ..... during II-fortnight of May.

Medium duration variety – Kesari – I fortnight of June

Long duration variety – Mubukur – II fortnight of June or July

Seed rate :

Varied with variety and region. Finger rhizomes are seed rhizomes. The mother rhizomes are used as seed. Seed rate is 2-2.5 t/ha. finger rhizomes : 1.5-2.0 t/ha.

Spacing :

Depending on the soil, it varies.

Black heavy soils - 46.23 cm

Red loamy soils - 30x15 cm

Sowing :

Differs with the system of cultivation. In ridge and furrow method, rhizomes are sown behing the plough and are covered with soil by the next ploughing. In bed system, rhizomes will be dibbled at a depth of 5-10 cm in the shallow pith.

Before sowing, seeds must be treated with Dithane M-45 3% or Agarmal 3%. After preparation of solution, rhizome dipped in solution and treated for 30 min as prophylactic measures to control diseases. After sowing, sprouting of rhizomes starts within 10-20 days which will be completed in 45-60 days.

Mulching :

Due to slow germination and slow growth at initial stages, different mulching materials used. Mulching is done to protect sprouts and conserve soil moisture to reduce weed growth. Mostly the dried leaves are used as mulch mat. After sowing the rhizomes, mulch is spread on the ground with dry leaves on which layer of cow dung is spread. II-mulching operation is done after 50-60 days after planting which coincide with weedings and fertilization.

Irrigation :

I – irrigation gives at immediately after sowing. Next irrigation gives at weekly intervals. Total of 15-20 irrigations given in clay or back soils. 30-40 irrigation required for sandy loam soils.

Manuring :

Turmeric is heavy feeder and it requires good amount of nutrients.

At the time of land preparation apply 20-25 t/ha FYM. Fertilizer dose : 60-60-60 kg/ha

Another dosage : 120 kg N/ha should be applied in 2 split doses.

I-dose @ 60 DAP lasting (60 kg)

II-dose @ 120 DAP

Each time after weeding only top dressing should be done. In this, 120 kg N-50% applied as organic, other 50% as inorganic manuring. After each application earthing up operation is done. Later irrigation must be given.

Intercultural operations :

Starts after 40-45 DAP. The number of weedings depend on soil type, intensity of weed growth. 3-4 weedings required at an interval of 60, 90, 120 and 150 DAP. Weeding and hoeing done simultaneously and plants earthen up.

Provision of shade is important in turmeric. Shade is provided by raising the castor plants on bunds in A.P.

Another practice in Karnataka is raising of Dhaincha.

Intercropping :

It is practiced in certain regions with short duration crops before they attain good growth. In Rayalaseema and Telangana regions maize and chilli grown as intercrop. Turmeric itself grown as itnercrop in Coconut and arecanut, as it tolerates shade.

Crop rotation :

Turmeric depletes the soil fertility very fast. We should not grow turmeric continuously on the same piece of land which will encourage the pests and diseases. To avoid depletion of nutrients, pests and diseases, it must rotated with crops like rainfed paddy, banana, beetle vine and vegetables.

Harvesting :

It comes to harvest within 7-9 months. The man season of harvesting falls during February-April in A.P.

Maturity is indicated by yellowing and drying up of the plants. Cut this dried portion to ground level and light irrigation given followed by light ploughing or digging the field with …… or ……. After ploughing or digging the rhizomes are hand picked. The rhizomes have root portion or soil adhering to it must be cleaned by cutting the roots and cleaned by washing with water.

Yield :

In India, average yield is 20-22 t/ha. in A.P., 25-35 t/ha.

Processing :

There are 4 important stages in processing.

1. Boiling
2. Drying
3. Polishing
4. Colouring

The fresh rhizomes are not used directly in market.

1. Boiling : It can be done by 2 methods.

a) Traditional method : Cleaned green rhizomes boiled in copper or galvanized iron or earthen vessels. Sufficient water must be poured for boiling. Mother and finger rhizomes boil separately because mother rhizomes take more time. Boiling can be stopped when the foath comes and white fumes appear with typical turmeric odour. When rhizome properly cooked, it become soft and break with fingers prenures. It takes 1 hour for boiling. Over cooking and under cookings are avoided. Over cooking spoils the colour of rhizome. Under cooking makes the dried products more brittle.

b) Improved method : Almost 50 kg rhizomes taken in perforated tough. Perforated tough prepared with G.I. sheet and immersed in the pan of boiling vessel and the alkaline solution of 0.2% is added. Mostly sodium carbonate or sodium bicarbonate and then boiled. Specially alkaline solution helps in imparting orange-yellow tinge to rhizomes.

2. Drying : The cooked fingers dried in the sun by spreading in 5-7 cm layer thick. Sundried for 10-15 days. Racking of rhizome is important for uniform drying. It will be continued until rhizomes become hard and brittle and gives metallic sound when breaks.

Moisture content is 8-10%.

Recovery percentage is 20-30%

3. Polishing : Dried turmeric has poor, rough and dull appearance with scales and small root portions. The rhizomes are improves by smothering and polishing the outer surface by manual

and mechanical methods. Manually polished by rubbing on the hand surface or trampling under the feet. Mechanically rhizomes polished by operating them in polishing drums.

4. Colouring : After polishing to give good appearance, it is artificially coloured. The half polished rhizomes coloured in 2 ways

1. Dry method

2. Wet method

Turmeric added to polishing drum in least 10 minutes in dry method.

Turmeric powder is suspended in water and mixed by sprinkling water in wet method.

By giving the bright colour, boiled, dried, half polished ones taken in baskets which can be shaken by mixing with emulsion 0.04 kg alum;

2 kg turmeric powder

0.14 kg castor seed oil

10 gm sodium bisulphate

All these are mixed in 30 ml of HCL.

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SEED SPECES

CORIANDER

(*Coriandrum sativum*)

F.Umbelliferae

Economic parts – Leaf and seed

Origin : Mediterranean region

Coriander is a annual herb, cultivated for green leaf and seeds.

It is considered as minor spice

One of the important seed spice

Uses :

- Fruits have a fragment smell and they have a pleasant aromatic taste. Hence used as a spice and condiment.
- Used for flavouring of liquor and confectionaries.
- Also used to mask the offensive odour specially in pharmaceutical industries.
- It is made into powder and one of important ingredient of chewy powder.
- Leaf is used for preparation of chutneys.
- Leaf is used for preparation of seasoning of various veg and non-veg food materials.
- It has medicinal properties used in Ayurvedic and Unani preparations.

Consider is commercially cultivated in India, Russia, Moracco, Poland, Romania, Gautemala, Mexico, USA, China and Thailand.

India is the largest producer of coriander seed spices.In India, it is cultivated in A.P., T.N., M.P., Rajasthan and Karnataka and Orissa. To certain extent it is also cultivated in U.P., Bihar, Maharashtra, Haryana. They are growing for seed purpose. For leaf purpose, it is grown throughout India.

Botany :

It is an annual herb, aromatic, erect growing herb reaching to a height of 30-90 cm depending on the variety.Stems are slender, smooth, branched at upper portion. Leaves are pinnately compound with long swollen petioles, alternate, lower leaves have broad segments where upper leaves having fine segments. In A.P., it is cultivated in Kurnool, Ananthapur, Cudapah, Medak, Guntur, Prakasam and Adilabad district. Fruit is botanically called as 'Schizocarp'.

Inflorescence :

It is compound umbel and each umbel consists of 2-6 umbellae and flowers are smaller in the size f white in colour. Coriander is considered as andromonoecious i.e., staminate and perfect flowers on same plant. Self and cross pollination occurs. Seed is having 2 carpels, each having 2 seeds.

Climate :

Mostly tropical and sub tropical crop. It requires cool climatic conditions during early stages of crop growth period. Requires warm, dry weather at maturity and cool at early stages.

If any cloudy weather condition at flowering and fruiting stage leads to incidence of pests and diseases, mostly powdery mildews. Dry weather at flowering flavours good grain production. Heavy rains effect the crop, moderate rainfall is essential.

Soils :

It comes up in variety of soils ranging from sandy loam to black cotton soils provided organic manure or soils rich in humus. Soils should be of well drained. It is raised as rainfed crop in heavy soils which have better moisture retention capacity. In SI, heavy black cotton soils are suitable for coriander cultivation.

Land preparation :

Especially for rainfed crop, 3-4 ploughings needed September-October (rainfed). Rainfed cultivation taken up under rice allows. It can also be raised as irrigated crop for land preparation, 2-3 ploughings. After land preparation, prepared the beds and channels. So, sowing can be taken up any time.

Seasons :

Depends on the purpose for which it is raised, leaf or seed.

For leaf purpose : Grown throughout the year.

For seed purpose : Varied depending on the region.

North India, Central India and A.P. : Sowing varies specially grown in rabi conditions. Mostly season ranging between mid October-mid November.

Tamil Nadu and M.P. : Grown during kharif for seed purpose only; mostly during June-July.

When rabi and kharif is compared, rabi yields are higher. Coriander is taken as pure crop or inter crop. Mostly cultivated as pure crop, when taken up as mixed crop it is grown with cotton and pulses.

Seed rate : 10-12 kg/ha

Seed rate differs with region.

In A.P., 12-15 kg/ha

Before sowing, seed must be trampled, crushed gently to separate mesocarp and soak in water for 12-24 hours and shade dried which will encourage good germination. Before sowing, seed treated with thiram at 2 g/kg seed.

Sowing methods :

Seeds broadcasted for rainfed crop and covered with plough. Under rainfed conditions, seed sowing taken up when sufficient soil moisture is available. Under irrigated conditions, seeds sown in rows at a spacing of 30-40x15 cm and sown at a depth of 3 cm.

Immediately after sowing, irrigation should be given. Germination of seed starts 10-15 days which may continueuupto 15-20 days. After sowing and germination of crop stand is very thick, thinning can be taken.

Irrigation : Generally after sowing, immediately irrigation is given.

A total of 3-4 irrigations are required during the entire crop period.

I – Irrigation @ II leaf stage

II – Irrigation @ branching stage

III - Irrigation @ flowering stage

IV – Irrigation @ seed filling stage.

Manuring :

Manuring is not given because mostly raised on fertile black cotton soils utilizing the residual fertility specially under rainfed conditions.

Fertilizer dosage : 30-40-20 NPK kg/ha

In addition to this 10-15 t/ha FYM is required. This is mostly followed in A.P. for rainfed conditions.

For irrigated conditions 30-40-20 NPK kg/ha

10-15 t/ha FYM

In addition to this 20-30 kg/ha of N is given at the time of flowering

Intercultural operations :

The crop should be maintained without weeds in first 30 days.

I weeding – within 30 DAS

II weeding – before rows close up

It can also be intercultivated two times with cultivator with monthly intervals to control weeds to provide good aeration and conserve soil moisture.

Harvesting :

The crop will be ready for harvesting in about 80-120 DAS depending on the variety grown, season of sowing. Kharif crop comes to harvest earlier than the rabi crop.

Harvesting indices : The green leaf will dry away in case of seed purpose. The grains or seed which is green in colour turn to brown or stem coloured.

Delay in harvesting must be avoided otherwise lad to shattering of seed material or splitting of seed during subsequent operations during processing and harvesting time.

Plants are cut or pulled and tied into small bundles piled up and kept in shade and left for drying some time. Shade drying is preferred to prevent shattering of seed material or recovery of good essential. After 2-3 days of drying, bundles threshed to separate seeds from plants. Winnowing and sun drying of seed material is done and reduce the moisture level (15.6%) for god storage.

After drying, seed stored in gunny bags lined with polythene.

Yield :

Yield varying depending on conditions.

Rainfed conditions : 4-5 q/ha

Irrigated conditions : 6-10 q/ha

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FENUGREEK

(Trigonella foenu.....)

Fabaceae/Leguminoceae

Origin : South east Europe

Economic part : Leaf and seed

Grown in India, Argentina, Egypt and Mediterranean countries. In India, grown in Rajasthan, M.P., U.P., A.P. and Maharashtra. India is one of the major fenugreek growing countries exports to other countries. India occupies 3rd place in exporting and 4th place in production

Uses :

- Fenugreek is the dried ripe seed of annual herb used as spice and condiment.
- Also used as leafy vegetable.
- Seed is powered and used for flavouring of dishes and for culinary purpose.
- One of the ingredient of curry powder

- It has medicinal value. It prevents constipation, indigestion. It stimulates the activity of spleen and liver.
- Also used in healthy therapies.

Botany : Here are 2 important spices

1. Common menthi – *Trigonella foenurigraceum*
2. Kasturi/Champa menthi – T.corniculatum

	Common menthi		Champa menthi
1	Quick growing habit	1	Slow g rowing habit
2	Characterized with erect shoots	2	Shoots remain rosette appearance specially when plants are in vegetative condition
3	Reaches to a height of 40-70 cm	3	Reaches < 40 cm
4	Commonly cultivated	4	Rarely ultivated
5	Light to dark green leaves	5	Possess dark green leaves
6	Small bisexual flowers white in colour	6	Light pink flowers
7	Slender pods, long and curl	7	Seeds small, flat and square shaped
8	Characterized by prominent beak pods	8	Deep furrowed pods

Climatic conditions :

It is a full season crop grown in tropical and temperate regions comes up well in warm climatic conditions. Hence, it is having wider adaptability. It is tolerant to frost and freeze. Heavy rains are not suitable. Light to moderate rainfall is required.

Soils :

It comes up well in different soils. Clay loam are best soils. pH range is 6-7. Fenugreek is fairly tolerant to salinity.

Land preparation :

Prepare the land after receipt of rains. It must be prepared well until fine tilth is obtained. It is grown both in rainfed and irrigated conditions.

Rainfed conditions – Flat beds are prepared

Irrigated conditions – Raised beds are prepared

In rainfed conditions, flat beds of convenient size is prepared. Seeds can be broadcasted on the beds. After broadcasting the soil must be racked by any branch and thin immediately irrigation is given.

Seed rate : 30-35 kg/ha.

Under irrigated conditions, grown on raised beds. Size of beds is 2-2.5 m width with 5-6 m length are prepared. Seeds can be sown in a line at a spacing of 60 x 30 cm. then irrigation is given.

Seed rate followed : 12-15 kg/ha.

Seeds start germination within 3-4 days and completes germination by 7-10 days. If it is thickly sown, then thinning can be done greater if crop is sown for seed purpose.

Irrigation :

Mostly grown under rainfed conditions in heavy soils. In irrigated conditions, grown under light garden soils.

Irrigations needed are 3-6

I Irrigation – Immediately after sowing
II irrigation – After 1st cutting of leaves
Others – 6-7 days subsequent intervals

Manuring :

Mostly grown under residual fertility of previous crop. Gives higher yields when manured.

FYM : 10-15 t/ha at last ploughing

When grown for leaf purpose, N gives at 10-15 kg/ha in 3 splits

I split – 1 month after sowing
II split – After I cutting
III split – After III cutting

When grow for seed purpose, dosage is 20-40-20 NPK kg/ha. Another dose of N at 10-15 kg/ha given at 1 month after sowing

Intercultural operations : We must keep weed free crop at early stages. A total of 2-3 weeding taken up.

Harvesting :

When grown for leaf purpose; I cut taken up at 20-25 DAS. Subsequent cuttings for leaf done are at 12-14 days interval. Almost we take 4-5 cuttings. After this, plants are uprooted. This must be completed before plants come to flowering. Cutting should not be delay because leaf give bitter taste.

When grown for seed purpose; one or two leaf cutting can be taken up and plants will come to flowering 30-45 DAS. When pods day up partially otherwise splitting and shattering of pods taken place. Then partially dried plants are uprooted and sundried for 2-3 days. Pods threshed and winnowed. Seeds sun dried reached to 10% moisture level and stored in gunny bags with polythene lining.

Yield :

Leaf yield : 7-9 q/ha

Seed purpose :

Rainfed : 7.5-8.0 q/ha and Irrigated : 12-13 q/ha

CUMIN

(Cuminum cyaminum)

F : Apiaceae

Origin : Mediterranean region

Ecomomic parts : Fruit or dried seeds

Uses :

- Very important ingredient in Ayurvedic medicine
- Used for flavouring of squash, beverages and confectionaries
- Important ingradientincurry powder
- Important spice in kitchen

It is grown commercialy in India, Israel, Saudi Arabia, Iraq, Moracco, Turkey, Eugoslavia, Bulgaria, Sudan, China and Java. In India, cultivated in Rajasthan, Gujarat, A.P, M.P., and Punjab. It is grown in tight soils with irrigation in Rayalaseema and Telangana regions of A.P India exports cumin to Malaysia, Australia and Eastern Africa.

Botany :

It is an annual herb about 30-45 cm tall, much branched with angular stem. Inflorescence is compound umber with whit or rose coloured bisexual flowers. Fruit is

cylindrical, tip is narrowed, ridged and some what dorsally compressed. Seeds are aromatic and light brown in colour.

Climate :

It is a tropical plant cultivated under rabi conditions, specially where he atmosphere humidity is low during February and March. If humidity prevails during flowering and fruiting lead to incidence of pests and diseases, mostly to powdery mildew. It comes up well from sea level upto 3000 m MSL.

Soils :

Requires well drained soils with medium to heavy textured soils but in heavy soils wilt disease is more severe. It can also be grown in slightly alkaline soils having a pH of 8.9

Land preparation :

Repeated ploughing done until fine tilth is obtained. Field is leveled and made into convenient sized plots depending on the leveling of the soil.

Seed rate : 8-15 kg/ha

Sowing :

The crop can be raised by broadcasting or line rowing. But before sowing see must be soaked I water for 24-36 hours to enhance good germination. In line sowing spacing is 15-20x15 cm. after sowing irrigation is given. Plants can be thinned out following the spacing.

Season :

In Gujarath and Rajasthan, where cumin is cultivated commercially, sowing can be done during mid November to last week of December. The temperatures are very congenial for good seed germination and survival of seedlings.

Irrigation :

I – Light irrigation is given after sowing

II – Irrigation. 6-10 days after sowing.

III – Irrigation after another week to help further germination

Later on irrigations given at 12-15 days interval

Irrigations must be avoided at maturity of seed otherwise effect he seed quality.

Manuring :

At field preparatn 12-15 t/ha of FYM

Nitrogen – 30 kg/ha in 2 splits

I split @ 30 DAS

II split @ 60 DAS

After, give one irrigation

Intercultural operations :

I hoeing and weedings done when plans reach 5 cm height. Subsequently, 2 hoeing done to encourage further growth.

Harvesting :

Cumin matures within 10-120 days depending on the variety. When seeds matured, palnts are uprooted, bundled, staked and kept for sun drying. Threshing can be odne by beating. After winnowed, sun dried, stored in bags.

Yield :

5-8 q/ha

Good management gives 10 q/ha of yield.

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PLANTATIN CROPS

Plantation crops are those which are used or whose product is used only after processing. These are the crops which are cultivated on an extensive scale in a large continuous area, commercially by an individual or any company and the produce has to be cured before they are put to use.

Plantation crops have high value commercially. They have greater economic importance. They play vital roe in improving the economy of the country.

Economic importance :

- Most of the plantation crops are export oriented

  Ex : Cashew nut, beetlevine, Arecanut and Tea.

- Plantation crops earn foreign exchange for the country and they occupy 75% of the total earnings from the export of the agricultural produce.
- These crops occupy 2% of the total cultivated area in the country but generate maximum income of 16,000 millions per annum.
- Plantation crops provide employment to the million of people

  Ex : In cashew nut plantations, it is providing employment for > 3 lakh people in processing factories.

- They support many of t he ancillary industries and rural cottage industries. Ex : Coconut coir industries and cashew nut.
- Plantation crops help in conserving the soil and ecosystem. Ex : Tea, coffee plantations grown in hilly tracks having slopes obstruct the soil erosion. Cashew nut cultivation in waste and barre n lands contains soil erosion.

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COCONUT

(*Cocos nucifera*)

F : Palmae

Origin : Indo Malayan region

Known as 'Kalpavriksha'

Importance of Kalpavriksha :

- It is the most useful palm of the world.
- It provides nutritious food
- Gives refreshing drink – Coconut water.
- Gives oils of edible and non-edible oils
- Fibre from coconut has commercial value
- The shell is used for fuel and industrial uses
- Coconut also produce thatch
- Used in alcoholic beverages
- Also used for preparation of miscellaneous products; Arts, Crafts and mulching purpose.
- Coir and pith is used as soil media
- It is an important source of vegetable oils
- On average it has 65% of oil content in kernel when compared to oil palm
- Copra and coconut oil are traditional commodities in world market.
- It provides employment to more than 10 million people directly or indirectly
- It is supporting ancillary industries like copra manufacturing, coir manufacturing and oil milling industries
- Export of coir and coir products earning nearly 260 million rupees/annum.

Botany :

Coconut is a tall unbranched palm growing to a height of 15-30 m. it has a stout trunk raising from the swollen base which is known as bole. It is surrounded by a mass of fibrous

roots. The stem is terminating into a radiating crown of leaves. Leaves are known as fronds. Leaves are large, long, pinnately compound. Palm is monoecious produces one inflorescence is enclosed in a strong tough double sheath called as spathe. When fully grown, it splits longitudinally and releases the inflorescence. Each inflorescence having main axis and 30-40 flower bearing spikelets. Male flowers are 250-350, mostly they will appear on the terminal portion of the spikelet. Female flowers appear at the basal portion f the spikelet. Female flowers are known as buttons. They are 2-5 in number and male flowers contain 6 stamens. Female flowers are tricarpic ovary.

Male flowers open canter than female flowers leading to cross pollination. Female flower production is high during March-May and female flower production is done during September-January. Insects are the pollinating agents.

Fruit is known as drupe, large in size, one seeded, round, ovoid I shape and the fruit has smooth thin green skin known as exocarp below which there is a thick fibrous hook known as mesocarp. Under this mesocarp or hook there is a nut having hard outer layer known as endocarp or shell. Thee is a testa which will be off brown or red which is adhering to the endocarp. There is a thick albuminous white endocarp which is known as meat or kernel enclosing the cavity filled with water. There will be an embryo at the tip of the meat.

	Dwarf varieties	**Tall varieties**
1.	Short statured (5 m)	Tall statured (30 m)
2.	Live upto 40-50 years	Live upto 80 years
3.	Earliness in bearing (3-31/2 years)	Late bearing (8 years)
4.	Trunks are without a bole	Have short trunk with a bole
5.	Fully developed leaf, measures 4 m rarely	Fully developed leaf, measures 6 m
6.	Exhibit alternate bearing habit	Regular bearers
7.	Autogamous (self pollinated)	Allogamous (cross pollinated)
8.	Nuts are small, copra is soft and leathery with low oil content	Nuts are medium to large; copra, oil and fibre are of good quality

9.	Mainly grown for tender suits and ornamental purpose Ex : Chowgat orange, dwarf; gangabordam; Malaya orange dwarf	Grown commercially for copra, oil etc. Ex : East coast tall, west coast tall in India Laccadive ordinary, Laccadive micro grown in Lakshadweep, Andaman and Nicobar islands
10.	Yields long. Poor quality of copra of 60-65%	Yields 700-1000 nuts/palm/year Copra : 165-175 gm/nut. Oil 7%

95% of coconut cultivated area in A.P.is under East coast tall.

Climate :

It is growing under various agro-climatic conditions. But essentially consider as tropical plant, growing @ 26^0N, 26^0S latitude. Though it is tropical plant, not tolerate extreme temperature. It is confined to a height of 600 m MSL. At equator, it is cultivated at an elevation of 1000 m MSL.

Coconut requires humid, warm climate with an annual temperature of 27^0C but the average diagonal variation should not exceed 7^0C. It will not furnish well where the annual mean temperature is $<20^0$C because this temperature impels the fruiting and flowering.

Coconut requires annual sun shine hours of 2000 hours with atleast 120 sun shine hours/month for the good potentiality. It comes up well in shade conditions. In shade, it becomes lancy without fruiting. It can tolerate wide range and high intensity of rainfall. Average annual rainfall is 2000 mm distributed uniformly gives good growth and yield. When there is no equal distribution of rainfall, drainage status, moisture holding capacity of soil yields reduced drastically.

Soil moisture deficit during summer months hamper nut production. Slight winds desirable but not the cyclones.

Soil :

It is adaptable to wide range of soils, light soils to heavy soils. In case of heavy rainfall are as, well drained soils are best. In poor rainfall areas with long dry spells deep fine soils with good water holding capacity are best.

But mostly clay and black cotton soils are subjected to water logging. But this is not suitable to coconut. Mostly, coconut is grown well in sandy soils. They give good crop if assured irrigation is given and manuring even sandy soils give good yields.

The laterite sols deep into 1 m without rocks had pan and also alluvial and red sandy loam, silt loams are also best soils if they provided with good drainage conditions. Alkaline and saline soils are not suitable. pH should be 5.2-7.0.

Land preparation :

Land must be prepared well. Ploughing must be done deeply and repeatedly in all directions. Remove all the rocks and root positions and level the land. If any slope is existing contour bunding or bunch terracing must be done. If water table is high throughout the year which leads to water logging conditions, raised mounts or beds must be prepared giving irrigation or drainage channels.

Planting :

Planting must be taken at beginning of south west monsoon. If irrigation facilities are available, planting must be taken even during May month also. Similarly in heavy rainfall area planting need to be taken up at the end of monsoon season. The new planting can be avoided the water logging conditions.

Spacing :

Depending on the variety soil type and type of culture spacing is varied.

For all tall varieties – 7-7.5 m in Triangular system; 7-9 m in square system

For dwarf varieties – 6x6 m in square system

When coconut is grown for monoculture, closer spacing is adopted and when grown as mixed or intercrop, wider spacing is adopted.

Digging and filling of pits :

Pits of 1x2x1 m are dug out during summer and left for weathering. Before planting, pith filled with top soil mixed up with river sand, wood ash bone meal, MOP and also for the control of termites, 50 of follidol dust. In case of sandy soils, 2 layers of coconut husk can be a…….. at the bottom of the pit and filled with soil.

After filling the pit, it must be watered for setting up the soil. The seedlings transplanted in the centre of the pit. After planting, seedlings must be stacked and watered.

Manuring :

Manural dosage of adult palm (tales) under rainfed conditions (kg/year/palm)

Once in year @ July-August

Year	FYM	N (g)	P (g)	K (g)
I & II	25	150	100	150
III	50	300	200	400
IV & V	75	450	300	650
VI onwards	100	600	400	800

Under irrigated conditions, the dosage recommended is double (twice in year @ June-July and Nov-Dec).

Organic manuring depending on the age increases. It must be applied during monsoon season. A trench can be dug around the tree and manuring should be done in that trench which is 2 m away from the base of the plant.

Irrigation and moisture conservation :

- Response to manures will be increased with irrigation
- Increased female flower production
- In light soils, low rainfall areas during long deep spell, the water should be irrigated.
- Basin flood or drip irrigation methods should be followed

- To conserve the moisture
- Mulch the …….. with coconut husk
- …….. coconut (5-6 year decomp) husk/dusk (8-10 year decomposition
- Buried alternatively at a depth of 0.5-1 m and 2 m away from the trunk.

Coconut husk uses :

- Acts as sponge and retains 8 times moisture to its net
- Retains moisture 6 times to its net
- Retains moisture slowly during day spell
- Adds K

Intercultivation :

Ploughed twice in winter and twice in rainy season Ploughing, digging and racking is done in basins and between the rows. Due to this aeration, infiltration of water contacts the formation of matting of roots and weeds.

Cover cropping :

- Checks the soil erosions
- Protects the soil from exposure to direct sun
- Contacts the rain drops affects on the ground
- Weeds may increase the organic matter in ……..
- Add N.

  Ex : Legumes

Mimosa invota

Stylosanthus grocilis

Galopogonium mucunoids

Intercropping :

Because of coconut's long pre-bearing period and lot of space between the rows we an go for intercropping. It is advisible till coconut com to bearing. Intercropping is discontinued after coconuts come to bearing. Intercropping is again taken up afterit reaches to the age of 25 years.

Ex : Banana, Vegetbles, groundnut, turmeric, ginger, tapioca, sweet otato and elephant foot yarn

Mixed cropping : Grow long duration crops.

- The crops should be shade requiring crops/tolerant
- They must be manured adequately and separately
- They must be irrigated adequately and separately

Ex : Cocoa, nutmug, cinnamon and black pepper

Harvesting :

Tall varieties begin flowerinrg 5-7 years after planting

Dwarf varieties – 3 years after planting

They come to bearing after 2-3 years after commencement of flowering. Then they produce continuous flowers and fruits as one inflorescence/month; 12 branches/year.

11-13 months period takes for maturity after flowering.

Harvesting done depending up on the purpose for tender nuts – harvest @ 6-7 months old.

Harvesting indices :

- Brown colour of the husk
- Hallow round on tapping
- Total number of harvests : 8-10
- Harvest for green husk – 10-11 months old
- For copra and oil – 11-12 months old
- For seed purpose – 12 months

- 45 days interval, the nuts harvested during summer and 60 days interval during rain.

Yield :

Varies depending on varieties, cropping systems, pests and diseases.

Rainfed conditions : 60-80 nuts/palm/year

Irrigated conditions : 80-100 nuts/palm/year

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OIL PALM

(*Elaysis guineanssis*)

F: Palmae

Origin : West Africa

American oil palm – South America

Commonly also known as African oil palm, Red oil palm

Economic use :

Gives important vegetable oil

These are the highest oil yielding palms

On an average, yields 2.5-4 t/ha

Coconut yields 0.6-1.6 t/ha only

Extensively cultivated in Malaysia, Indonesia and Srilanka

Oil palm was introduced to India in 1834 (plant not survived) and later in 1930.Again introduced in 1970 where commercially cultivated in India. Introduced to Kerala first. 1970 – Introduced oil palm India Limited Later ICAR committee recognized almost 10 states in India; A.P., Assam, Goa, Karnataka, Kerala, Maharashtra, Orissa, T.N., Tripura and W.B. In A.P.,

identified 10 districts. They are Srikakulam, E.G., W.G., Prakasam, Visakhapatnam, Krishna, Nellore, Vizag, Guntur, Khammam.

Botany :

Oil palm has unbranched stout tree. It grows to a height of 15-30 m. its height depends on variety and environmental conditions. Crown contains 30 leaves or fronds. These fronds are compound with a prominent petiole. They arise in whorls. Palm has strong root system to withstand strong cyclones and hailstorms.

Inflorescence is spadix and is axillary. Spadix is enclosed in a spathe. This spathe splits longitudinal exposing the flowers. Spadix has main axis having 4 or more laterals which has the flowers. Flowers are the florets.

Palm is a monoecious. Male and female flowers are separate but present on same plant. The individual flowers in female spadix arranged spirally on the axis and each spikelets protected by fine wax. Female flowers emit pleasant fragrance which attract insects helped in pollination.

Male inflorescence born on a large peduncle and contain long finger like spikelets. Each spikelet bears 1100-1200 small flowers. Oil palm is a cross pollinated plant. The main agent for cross pollination is wind and insect *Eeidobius kamarunicus*

The fruit bunches net is 14-30 kg. Fruits are oval in size 2.5-5 cm long. They are dark green with violet tinge, ripening fruits turn orange or yellow colour. Fruits ripen in about 6-9 months after pollination. Fruit is a sessile drupe. Fruit consists of exocarp, mesocarp and endocarp i.e., shell. These are enclosing the kernel.

Climate :

Oil palm is considered as a tropical plant. It requires rainy tropical climate. Grows well in areas having mean annual temperature of 20-35^{0}C. The mean annual rainfall ranging from 100-

1000mm. this rainfall must be well distributed with atleast 100 mm of rainfall/month. It can also withstand rainfall of 900 mm.

It can withstand drought for 2-3 months. Hot humid equatorial climate without long dry period is best. It requires plenty of sun shine hours. There should be frequent change of sunshine and rain. It comes up well from the elevation of 450 to 900 m MSL.

Soil :

Variety of soils are suitable for the cultivation of oil palm. Deep loamy soils rich in humus are suitable. Forest soils with loam and clay content in sub soils are suitable. Lateritic sandy and pure clayey soils are not suitable. Waterlogging soils are not suitable. Oilpalm can tolerate salinity upto 0.5%.

Land preparation :

At the beginning f rainy season, land preparation is started. Clear all the vegetation and plough the and thoroughly.

Digging and filling of pits :

Pits are dug out during summer season with the size of 60x60x60 cm following the spacing of 9 m is triangular system of planting. Pith left for weathering for 2-3 weeks. Pith filled with top soil, mixed with manures and fertilizers and then watered to settle down.

Planting :

Planting can be done during rainy season. Polybag is cut and seedling is separated from the poly bag intact with all of earth and root system. Seedling planted in the centre of pH. Collar region of plant should not buried into the soil. Care to be taken that collar region is level to land surface. Deep planting is avoided. After planting, it is watered and seedling is protected and mulching can be done in basins. After establishment of seedling, manure and fertilization can be done.

Manuring :

Regular manuring programme is very essential

Fertilizer (kg/palm)	Age of palm (months after planting								
	2	4	6	9	12	15	18	24	30
N	60	80	120	160	180	200	250	300	400
P_2O_5	-	230	-	230	-	320	-	360	360
K_2O	150	150	150	180	240	300	360	600	600
$MgSO_4$	-	250	250	300	300	300	300	500	500

FYM 25-10 kg/palm depending on age and type of soil This fertilizer dosage can be applied in 2 splits

Doses :I split @ June-July

II split W Sept-Oct.

A broad band/trench can be made around the palm underneath the spread of the leaves fertilizers applied in trenches and covered with soil and watered immediately

Intercultivation :

Weeding : Competition must be avoided between young developing plants and unwanted plants. Basins kept weed free. In case o young gardens, the barings or rings around the palm needed out. In case of bearing gardens, the entire land is ploughed/weeded twice in a year. Herbicides are not used to control he weeds.

Leaf pruning : It is done during the dry months. Prune dead, dried out and diseased leaves. Male inflorescences must be cut. It must be practiced to avoid shade by overcrowding leaves; uniform ripening of bunches of crown. It also avoids the obstruction at the time of harvesting.

Cover cropping :

Cover cropping checks the erosion

Suppress the need growth

Adds fertility to the soil

Ex : calapogorium mucunoides

Purarania phaseoloides

Denonsema pubescence

Flowering and cropping :

Production of fruit bunches start at the age of 3-6 years but peak bearing is observed when attain 8 years age. It will continue bearing upto 40 years or more. The fertility period is upto 60 years. The palm lives for about 100 years.

Harvesting :

Fruits harvested after full ripening.

Harvesting indices ; Change of fruit colour from red to orange

Dropping of fruits from bunches

After harvesting the bunches

Shifted to processing units within 24 hours.

Yield :

In A.P. the average yield is 20-25 t/ha – fresh fruit bunches

The oil yield is 4-6 tons.

Oil palm gives 2 distinct vegetable/edible oils. Oil yields from mesocarp of fruit is 20%. Oil yields from kernel of the fruit/seed is 26%. Total of 46% comes from the oil palm

ARECANUT

(*Areca catechen*)

F : Palmae

Origin : Malayan and Archepelago islands, Indian islands and E.I. island.

It is one of the important spices in India. Cultivated since pre-christian era.Commercially cultivated in India,Bangladesh and Sri Lanka. In India grown in Kerala, Karnataka, Assam (which accounts >90% of total area in the production of arecanut), T.N., Goa, W.B., Meghalaya, Maharashtra and Tripura. In A.P. grown in an area of 200 ha only. It provides employment to 6 million of people directly or indirectly.

Botany :

It is an unbranched smooth, cylindrical inflorescence called spadix enclosed in a spathe. It is a thorny, slender palm and grows to a height of 15-20 cm.

The spadix consists of main rachis and is divided into secondary and tertiary rachis. Both male and female flowers arise on them. Female flowers are unisexual. Male flowers arrange on upper part and mostly at dorsal end of secondary rachis. Male flowers are smaller than female flowers. Staminate flowers open earlier than pistillate flowers which encourage cross pollination.

Fruit consists of fibrous outer husk enclosing the single seed. Fruits are bright orange in colour. Fruit is nut and takes30-35 weeks for the maturity.

Climate :

It is a tropical palm, comes well in different agro-climatic conditions and grown well from 1000m above MSL. Cultivation mainly continued to 28^0N and S of the equator. Arecanut grows in areas which receive abundant well distributed rainfall hence it requires moist climatic regions.

Optimum temperature 15-30^0C. it cannot tolerate extreme temperature and wide diagonal temperature. Banana is an intercrop in this plantations.

Soil :

Arecanut thrives well in variety of soils provided good drainage conditions. Red laterite, red loamy and alleviated soils are suitable. It cannot withstand water stagnation. Drainage must be provided in the areas of high rain fall regions like Assam and West coastal regions.

Land preparation :

Repeated ploughings must be done after the fine depth is obtained.

Digging of pits : Pits are dug out with a size of 90x90x90 cm with a spacing of 2.7x2.7m. pits filed with compost and tank with seedlings planted at the centre of the pit at the beginning to end of the monsoon.

Bananais planted in Arecanut to give prrotectin for seed scortching. It is planted during May-June in well drained soils as Aug-Sept in clay soils.

In Tamil Nadu, banana is planted during June-July. Arecanut during October month is very susceptible to sun scorching. Plant rows may planted in N-S direction at an angle of 30^0 towards west. Tall and quick growing shade trees raised in south and south west side to provide shade.

Irrigation and drainage :

Rainfed and irrigated crops, irrigate the crop once in 3-5 days. Arecanut is very sensitive to water logging conditions. Drainage must provided at a depth of 30 cm, for every 2 rows of palms to drain out excess water.

Manures and fertilizers :

Manures and fertilizers should be applied at every year. Dosage of N, P and K = 100-40-140 kg/ha. 12 kg green leaf manure, compst can apply. Organic manure applied only once or a year at September and October given in 2 split doses.

I split : Sept and Oct (broadcast around the palm)

II split : March and April (rainfed) applied in a trench of 75-100 cm radius.

The recommended dosage for …….

If soils are acidic in nature, apply lime during 3 weeks prioir to fertilizer application. Liming done at alternate days.

Intercultivation :

Control the weeds with a light digging, done at the end of monsoon by breaking the crust i.e., found during irrigation. Hand weeding should be done regularly.

Cover cropping : Followed I the areas of sloapy lands.

It prevents the soil erosion

Adds organic matter

Usually cover cropping practiced at the beginning of the season,which ads .....

Ex : *Stylosanthus gracilis*

Calapogonium murunoids

Interspacing between rows is utilized by growing the cover crops.

Intercropping with banana, ginger, turmeric and elephant foot yarn

Mixed cropping with beetle vine, nut meg

Yield :

Almost > 10 kg/palm

12.5 -15 q/ha.

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CASHEWNUT

(A*nacaudium occidentale*)

F: Anacaudiaceae

Origin : South America

Cashewnut is an exotic crop, introduced to south India by Portuguese during 16th century.

It can grow upto 200 latitude, and grown > 30 countries like India, Brazil, Tanjania, Kenya and Mossambe. India stands first in production of cashewnut. It produces 90% of world's exporting market.

In India, important states are Kerala, Tamil Nadu, A.P., Maharashtra, Goa and Karnataka. Others are W.B., Tripura and Pondicheri. In A.P., Guntur, West Godavari, Nellore and Prakasam districts.

Uses :

- A labour intensive crop. Needs more labour for processing.
- Provides employment > 4 million people.
- Earns good foreign exchange – 2% by exporting the agricultural products.
- It is nutritious food. Low in carbohydrates and rich in vitamins.

- Yields 40% of oil
- Testa is rich in tannins, used in leather industries. Testa which is adhering kernel an be utilized for poultry feeding.
- Very rich in Vit-C and five times more in citrus yields 10-20% of sugar.
- Astringent presenting cashewnut is not consumed but used for preparations of liquor, 'Feni' prepared in Goa.
- Cashew nut shells can be dried and make powder, used for animal feed. It is very rich in phenol used for preparation of pains, insecticides, baking and good preservatives.

Botany :

Cashewnut plant is an evergreen close spreading tree and reaches to a height of 10-15 m with primary and secondary branches. It has very strong tap root system by extensive network of lateral roots.

Two types of branching is in cashewnut

1. Intensive branching
2. Extensive branching

Intensive branching : shoots grow to a length of 25-30 cm, temperates into a panicle. 3-8 laterals will arise from below the panicle within 10-15 cm of the apex. These laterals again terminate into panicle in the next flowering season. This process of branching will be reported giving plant to a bushy appearance.

Extensive branching : Shoots grow to a length of 20-30 cm and take rest. Buds will sprout 5-8 cm below the apex and then gives further growth. This growth continues for about 2-3 years without lowering. This type of extensive branching gives the plant to a spreading habit.

This type of intensive and extensive branchings seen on same plant with varying extensions. High yields of > 60% of intensive branching, lone yields < 20%.

Leaves are alternate and simple, glabrous, obvovate, round, pinnately veined; young leaves are reddish brown to pale green gradually turns to dark green.

Cashew is a polygamous monoecious tree, flowers are bisexual or staminate and they are intermixed or present in the same inflorescence. In the inflorescence 95% are staminate and 5% are hermaphrodite. Inflorescence is terminal.

Flowering occurs in 3 phases

1. Male phase : Appear result in more staminate flowers
2. Female phase : More hermaphrodite flowers and then male phase.
3. Mixed phase : Most productive. It has staminate and hermaphrodite flowers.

Staminate flowers open earlier than bisexual flowers

Pollination is by insects – Files, bees and anti and wind. Under normal conditions, 85% of perfect flowers are fertilized among these, 4-6% reach to maturity.

Remaining shed at various stages of the development. Cashew is having a fruit called as cashew apple. This cashew apple is fleshy peduncle. It is not the true fruit i.e., real fruit. Cashew apple is juicy, sweet and varies in size, shape, colour and taste. It is 5-7 times heavier than nut. It is the rich source of Vit – C and sugars.

Cashew nut is the real fruit. It is a drupe. It is kidney shaped, green colour, vary in size and shape and nut will be growing ..... Shelling per cent is 13-30%. Nut encloses a soft kernel. It is the commercial product. Shell of he nut is sticky, resinous and corrosive oil called as cashew nut shell liquid (CNSL).

Climate : It is a heavy tropical plant, grown in wide range of tropical climate between 25^0N and S latitude, grows upto elevation of 1000 m MSL. Profitable cultivation is observed at 600 m.

It requires annual rainfall of 500 mm comes up even under 300-400 mm. rainfall distribution should be even. Distribution of the rainfall is important than quantum of rainfall. Rainfall must be spread to 5-7 months with a well defined dry season for about 3-4 months before flowering.

It thrives under the temperature of 15-40^{0}C. Cultivation is commercial in the areas with mean annual temperature not < 20^{0}C, but it is sensitive to extreme dry conditions. It is exposed to these dry condition, leaves get scortch and drop-off. Flowers and fruits also drop.

Cashew is sensitive to cold conditions and also grown under wide range of ..... nearer to sea coast upto 160 km, but excess humidity leads to pest and disease attack.

Soil :

Grown in wide varieties of soils. Laterite soils, red and coastal sands are preferable. Cashew is grown in marginal soils generally. In east coast areas, cashew is grown well in sandy soils. In west coast areas, grows well on lateritic soils, also grown on hilly slopes on western ghats.

Soils should be deep, feasible, well drained without any ..... with water table @ 3 m depth is best suitable.

It can tolerate drought to some extent but cannot tolerate water logging. pH should be 6.0-7.5.

Preparation of land :

Clear up all the vegetative growth and plough until fine tilth obtained upto 4-5 cm and then level the land.

Pits are dug up 50x50x50 cm during April-May with spacing of 8-10 m and planted as square system. Pits left for weathering for 2-3 weeks. Pits refilled with top soil mixed with 25 kg of FYM. 2-3 months old seedlings or 1 year old growth are planted in the centre of the pit during July-August. Watering is done immediately after planting provide support for planting called stalking.

Irrigation and manuring :

Cashew grown as rainfed and irrigated crop. It is a handy and drought tolerant plant. Irrigation must be provided during initial growth of 2-3 years, during summer irrigation must be given for better establishment of newly planted young trees.

Manuring :

Application of manures and fertilizers to get higher yields. During initial years vigorous growth. N applied once in 2 months.

Year	June-July			September-October		
	N (gm)	P	K	N	P	K (gm/plant)
I	25	25	25	25	25	25
I	100	25	25	100	25	25
III	150	40	60	150	40	60
IV	200	50	60	200	50	60
V	250	60	60	250	60	60

After 5 years; 500-125-125 g/plant/year in 2 splits

FYM : 25-50 kg/plant depending on the age. It is applied in the trench of 10-15 cm deep and 1-1 ½ m radius from the trunk and fertilizer mixed with FYM. Trench is covered and irrigation is given.

Intercultivation :

Weeding : The interspaces must be ploughed twice in a year starting from rainy seasons at the end of season. Ploughing controls weeds increase the infiltration rate of water into the soil. The young garden kept weed free by periodical weeding done in basins. After weeding, basins can be mulched with any dry leaves or paddy husk Mulching helps to conserve the soil moisture during summer.

Intercropping : Interspaces can be well utilized with GN, HG and cone ea. Also used for raising the nurseries of vegetables. In A.P., Orissa, interspace is used for raising the casuarinas. In Goa, it is used for Eucalyptus and Teak. In West coastal plane areas, coconut is grown as intercrop.

Pruning : Pruning is done. All side shoots must be removed upto height of 1 ½ m height. This helps the plant to give umbrella shape. Periodical pruning of diseased, rotten, criss-cross branches during blooming and harvesting periods i.e., June-December. Pruning helps the spread of diseases.

Flowering and harvesting :

Comes to fruiting in 3-5 years. Commercial bearing is only after 10 years. Comes to flowering only once in a year. The commencement of flowering season depends on the region.

In west coast region .....

In east coast region - January-February

Harvesting in west coast - February

Harvesting in east coast -April.

By May, all most all pickings can be completed. Fruits will be collected which are fallen down. In Goa, fruits picked up before they using preparation of berries. After harvesting, nuts are separated from cashew apple. These nuts sun dried for 2-3 days and stored in gunny bags.

Drying must be done properly because there will be discolouration on drying. Not also over dried, the nuts become brittle and breakage of kernels while processing.

Yield : Varies with variety, soil, rainfall, sex ratio, fruit set and management practices. Also varies with seedling progeny and region to region. In A.P. when plant is at the age of 15 years, nut yield is 1600 kg nuts/ha (16 q) higher.

Kerala : > A.P. yields.

Processing :

Kernel is enclosed in hard shell. Removal of kernel from hard shell is known so processing. It is done manually in a cottage industry. In Kerala at Quilon – More proessing units in India.

In A.P., Palasa (Srikakulam), Vetapalem (Prakasam) and Mori, (East Godavari) units

Processing involves various steps :

1. Roasting
2. Sheling
3. Drying
4. Pealing
5. Grading
6. Sweating
7. Packing

1. Roasting : It is done by three methods.

1. Open pan method

2. Drum method

3. Oil bath method.

Cashewnuts roasted for easy shelling and loosen the kernel inside. Roasting can be done in the above three methods.

Open pan method : Nuts are roasted in perforated open pan, made of iron. It is kept over a fire. CNSL oozes out during roasting and drips through perforated hoks causing heavy smoke fumes. Nuts catch the fire, water is sprinkled over the nuts to put-off fire, then thrown on ground quickly covered with soil for cooling and to absorb CNSL.CNSL not recovered.

Drum roasting : Nuts are roasted in a rotating metal drum. Drum is held in slanting position, rotting with handle and is heated from below. Nuts placed n one side of drum. Hotness of drum cause the fire of nuts within 3-5 minutes and nuts reach to other end of drum and get roasted. Temperature is 100-1200C. The CNSL comes out, nuts burns. The burning nuts are collected

from fire to put off by sprinkling water and by covering with soil. The rate of shelling and recovery of whole nuts is very high in this method. CNSL is not recovered.

Oil bath method : Nuts are held in wire trays and allowed to pass through the bath heated CNSL. Temperature 190-200^{0}C. nuts take 1-3 minutes while passing through CNSL, nuts ruptured and then releases the shell liquid. Then the nuts are removed and kept for cooling. In this process 50% CNSL is recovered. This method helps in uniform roasting and eliminate the …….. of nuts.

Shelling :

Process of breaking of nuts to extract the kernels – shelling. Roasted nuts broken with wooden ……. Great care is taken to obtain whole nuts. After cracking this nuts, kernel is obtained with help of needle or wire. Shelling percentage is 15-30%.

Drying :

Extracted kernels dried in wire mesh trays, hot chambers at 80-90^{0}C for about 6-7 hours. Drying helps to loosen the testa, which in adhering to the kernel and facilitate easy pealing.

Pealing :

Thin testa of reddish-brown colour is removed manually. Removal of thin testa from kernel is known as pealing. A laborious process. Care should be taken (Gives bitter taste).

Grading :

Grading is based on number of kernels. It is also done manually but grades which are common are:

a) 210 count – Zamboo wholenut. Bigger size nuts. Best quality
b) 240 count – Zamboo whole nuts, bigger size
c) 280 count – American quality
d) 320 count – Standard quality
e) Splits count – Whole nut split into 2 halves
f) Baby pieces

g) Broken buts

Sweating :

Drying makes grey brittle liable to easy breakage during package and transport. RH 80% for 5-6 hours and humidity is maintained. So kernels become less brittle and absorb moisture.

Packing :

Conditioned kernels packed by vita pack method. Tins fitted with kernels and vaccumised and filled with CO_2 and sealed. Packing must be done separately with gradings.

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CACAO

(*Theobromo cacao*)

F : Sterculiaceae

Origin : Amazon valley of South America

It is a beverage crop introduced by East India Company during 1796 and spread to Tamil Nadu and Kerala.

Comercialised during 1960s (During III five year plan).

Grown countries : Brazil, China, Ivary coast, Nizeria, Malaysia (Major) – 85% of world's area.

Major consumers : USA, USSR, Germany, Japan and France.

Cultivated in 30,000 ha in India. Grown as mixed crop in coconut and arecanut

Gardens in 79% area followed by Karnataka 19% aand TN 3%. Annual production is 8000 tonnes. Kerala – 71% production, Karnataka 25% and Tamil Nadu 4%.

Exporting 1000 t/year.

Uses :

- Important food crop and as a beverage crop

- Fermented, dried, roasted cacao beans called as cacao ribs. They are used for preparation of cacao butter, powder and chocolate.
- Cacao ……. ground to liquid form having 55-58% fat and this can be reduced to 28-33% known as Cacao ponoder.
- The liquid form after removal of fat content is known as coco butter, used for preparation of chocolate, drugs and soaps
- Cocoa mass mixed and sugar and butter to prepare the chocolates. Different ratios of sugar and butter milk give different taste to the product.

Botany :

There are 20 species of cacao are present Cola acuminate, the nuts produced by it are called as Cola nuts. It is producing a stimulating principle called as Coca cola. It is semi deciduous perennial plan, 5-8 mt height with dense foliage of round canopy. Round trunk with 1-1 ½ m branches. Branches arise in the whorls in a horizontal fashion and branches are called as Jarguetts/fans. This process of branching is known as Jarguetting. The terminal growth ends up in jarguetting and further growth is by suckers, known as Chupans giving the plant to umbrella shape.

Jarquets grow vertically and they end up with jarqeuttes. This process continues. Cacao is called as cauliflorus plant, flowers and fruits born on the old wood on the trunk or main branch. Inflorescence is compressed cyme with short branches, and peduncle. Flowers are hermaphrodites.

Fruit is a pod. It is indehiscent drupe. Pods are varied n size, shape and colour. Pods are elliptical to ovoid in shape. Pods are ribbed to smooth, yellow/orange/purple or brown in colour. Seeds are present in pod are called as beans upto 20-25 in number. These are embedded in the pinkish/whitish/bluish mucilage. It will be acid to sweep and aromatic in taste. Seeds are flat, round and white or brown/purple and taste also differing from sweet to bitter in taste. Seeds have two white or purple cotyledons.

Cacao flowers are both self and cross pollinated. It takes place by thrips, ants and aphids. Fertilization takes place in 36 hours after pollination. Pods mature within 150-180 days. Pod colour turns to light yellow when it is ripe and then ready for harvesting.

Climate :

It is the crop of humid tropical region. It requires optimum temperature of 25^0C, minimum of 15^0C and maximum of 40^0C. When the temperature is < 25^0C, the growth of the trunk is flowering will be affected. Seasonal variation should to be too narrow and it grows best near to the equator and having 10^0N and 10^0S latitude and also comes up well at 20^0N and S latitudes. It receives high humidity upto 80%. Though RH 80% is favourable, it encourages pests and diseases particularly under shade conditions. It is grown under lower attitudes, grown at a level of 700 m above MSL. Performs best when the elevationis 200-300 m.

It grows under wider rainfall of 1000-3000 mm per annum. It must have day season atleast for 3 months. Distribution of rainfall is more important than total amount of rainfall. 100-150 mm/month of rainfall is received atleast for 9 months in a year. Ideal rainfall is 1500-2000 mm. in low rainfall areas, it can be grown under irrigated conditions. Highly susceptible to strong winds because shallow roots. Hot winds to low humidity cause defoliation, dehydration of floral parts and organs.

Soils :

It can grow in wide range of soils. Rich in humus, rich in K, well drained soils. pH is 4.5-8.0. Neutral soils are best. The soils should be deeper > 1.5 m without any head pans particularly in low rainfall regions. It requires regular supply of moisture. Water able should be beyond 2-2.5 m. Cacao is well grown in low stored forest regions grow well under the shade of coconut and arecanut. It is sensitive to drought situation and water stagnation n soil.

Shade regulation :

It requires shade when plant are young, also gown up some extent. It grows best with 50% of sun light. It is established by 3 methods.

1. By planting the permanent shade trees. Plantations after cleaning the forest areas. It is practiced in West Indies and South America.
2. By thinning the existing jungles., West Africa.
3. Inter cropping/interplanting in coconut/arecanut plantations. Practiced in India, Srilanka, Malaysia and Newguinea.

Cacao can also be grown as a pure crop by thinning jungles. Shade can be regulated. Cacao grown with other crops to save land and extra income.

Spacing :

In arecanut plantations; 2.7x2.7 m grown in alternatively i.e., 5.4x2.7 m

In coconut plantation 7.5x7.5 m cacao can be planted as a single row following a spacing of 2.7x2.7 m cacao can be planted during South west monsoon, September-October and May and June.

Establishment of the plantation :

It is a shade loving plant. It requires adequate sun light. Extra branches should be pruned out for harvesting and spraying operations to carry out easily. Pruning also controls the pests and diseases.

Pruning is two types.

1) For development of shape..... shape pruning
2) Maintenance of pruning.

Shape pruning : Here, the I-jarquetting occurs during I year at a height of 101.5 m. there ill development of chupons. This can be checked out at this stage. Shape pruning is done by periodical removal of chupons during the initial stage itself. Shape pruning is continued and repeated till 3 carriers obtained giving firmly closed umbrella shaped. Canopy at about 2-2 ½ mt height.

Maintenance pruning : Remove all surplus branches, any > 5 pruned all side branches removed, if any branches growing upwards, they are nibbed/removed. Diseased, damaged branches can be pruned off.

Cropping :

Cacao comes to bearing II-IV year after planting. It gives 2 main crops i.e.,

I – October-January

II- Mid crop of April – June.

Off season crop : When grown under irrigated conditions.

Harvesting :

Harvested matured riped pods which turns to yellow or orange-yellow colour. They can be harvested at 10-15 clay by cutting stalks without injury to cushion area. Harvesting should not be delayed as it is characterized by vivipary.

After harvesting kept aside for 2-3 days then go for processing.

Yields :

Very low in India (Rodents and negligence). Dry beans yield – 4-5 q/ha

Average yield – 5-10 q/ha in other countries like Brazil and Malaysia.

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BETELVINE

(*Piper betel*)

F : Piperaceae

Origin :

Uses :

- It is a perennial aromatic creeper.
- Providing lively hood to more than 50lakh people.
- Leaf is chewed for digestion.
- Important in Hindu ceremonies.
- Rich in Vit-B, Vit-C
- Rich in Fe, Ca and P
- Also contain proteins, low fat (0.8), ... (6.1%)
- Rich in chlorophyll content, very proteinaceous.
- Very good tonic to brain, liver and heart
- Have cleaning effect of mouth

Grown in moist and sub tropical regions of India, Bangladesh, Burma and New guinea. In India, grown in M.P., Karnataka, Tamil Nadu, Assam, A.P., and West Bengal. In natural conditions, cultivated in Assam hills and West Bengal.

In artificially other parts of India (i.e., by growing the standards). In A.P., almost of Rayalaseema, Guntur, Nellore, Visakhapatnam districts. More production is from Rayalaseema regions and exporting to foreign countries and other states. Major importing countries are Pakisthan, Oman, Saudi Arabia, U.S.A and U.K. India is earning more than 1 crore rupees by exporting.

Botany :

Perennial, dioecious, climber and semi woody creeper, climbs with a support with adventitious roots born at the nodes. These roots can enter into cracks and ..... of the support and get attached to the support. Because of sticky substances, it gets fixed to the support. Grows to a height of 3-4 m within a year. The leaf size varies with variety. Vine is dioecious plant with minute flowers. Floering is seen very rarely (in old plantations).

Climate :

It is a pseophyte. Forest conditions are suitable (shade, coolness and humidity), requires regular supply of water. Climate of tropical forest conditions in south west India and north

western Indian natural conditions. In artificial conditions, we should provide shade, humidity, moisture and structures like live plants in and around the garden. In north India, stone walls/brick walls are constructed around the garden to protect from the hot winds, day winds and cool winds. ..... also erected. Requires rainfall of 250 cm/annum. Grown in very low rainfall areas of 25 cm rainfall under irrigated conditions. Grown upto elevation of 900 m above MSL.

Requires moderate temperature. Too low and too high temperatures are not suitable. Dry winds may ..... the leaves and leaf tips (low market value). High wind speeds cause turning of the leaves. (On temperature cause early defoliation of the leaves).

Soil :

Requires high fertile soils, well drained soils with high moist retention capacity, cannot withstand salinity and alkalinity. Always avoid very deep soils with imperious layers. Also avoid saline soils. Under poor drainage conditions vines turn to yellow, and have very short life. Clay loams with humus with more availability of P and pH of 8 are very good soils. Particularly grown in banks of rivers, lakes and canals.

Propagation :

Propagated by terminal cuttings.

Land preparation :

Choose the soil application of bulky manure. If available ..... river/pond silt help to increase water retention capacity. Plough the land repeatedly layout plantation.

Cropping :

Betelvine grown as intercrop in coconut and arecanut gardens, need not require special land preparations. If it is grow as pure crop, we have to grow wind break, shade plant and provide facilities for irrigation. Thinning should be done in forest areas and no need in already established garden.

Fencing :

Very thick and fine fencing or borbed fencing or can build a compound wall. Banana also grown as wind breaks (wild canes, bamboo). Wind breaks can allowed to grow upto 6 m to withstand speed winds. Standards are alive or dead plants. In natural forests, forest plants act as standards. When betelvine is grown as intercrop, coconut or arecanut plants are the standards. Sesbania, cassia can also be used as standards (commonly grown). Enthrina indica can also be grown but they have slow growth.

Advantages of Sesbania grandifolora : provides fodder, acts as standard.

Disadvantages : At the time of sowing, grows 2 sesbania and 2 Erythrina.

Sowing of standard :

Go for thick sowing, later thinning is done leaving 15-30 cm spacing. Sow when rain received during May-June. Sown on either side of ridges giving and spacing of 5 cm.

Training of standard :

Trunks should be smooth, don't allow side branches as it will obstruct the climbing of betelvine. Side branches can be removed upto 1.5 – 2 m height. Removing should be completed in 1 year

Disbudding can be done. Excess bit of standard is also not allowed. So do the stopping at a height of 4 m as the 4 m side branches will encourage and provide shade.

2 or 3 standard plants tile together to provide entire strength followed in Karnaaka and A.P. standards sometimes trained as Arch by tieing the tops of one bed with second bed. If these are not followed, the leaves exposed to sun light and develop sun scald.

Types of planting :

Betelvine can be planted in 2 systems

a) Bed system and b) Trench system

Bed system : Beds of 45 m length and 1.5 m width are prepared. Between the 2 beds, irrigation or drainage channels are provided. These beds are locally called as Peda.

Trench system : Trenches of 30 cm width, 30 cm depth are dug out. Cuttings are planted in these trenches. Terminal cuttings known as setts, are planted. They will established within 3 weeks. First leaf will develop in a month, after establishment. Vine must be trained on to the support.

Training of the vine :

Training of the vine must be done 1 month after planting. Vines start training on ground. At this stage betelvine must be trained on to the standard plant. Training is done by tieing the vines along the standard loosely with the help of gunny thread or banana leaf fibre with a interval of 15-20 cm. vines can come in contact with standard and strike the adventitious roots at nodes which help to cling to the support. Training must be done at fortnightly interval.

Lowering of the vine :

Very important in betelvine. It is done 1- 1 ½ years after planting. All the leaves present on the vine must be harvested except the terminal leaves. After harvesting of the leaves, the vine is removed and coiled carefully at the base of the standard dug up a small trench and burried the coil in the trench leaving 30-60 cm length of terminal growth. Trench is covered firmly and soil and light irrigation is given. After one month veins are trailed to the standard plant and cared until the next lowering of the vines.

Reasons for lowering of the vine :

Under natural conditions vines grow to a height of 3-4 m/year. And the vigorous growth produces normal size. Leaves will be reduced to these vines need rejuvenation in the vines.

Water requirement of vine is very high. When adequate water is not available, lowered vine require less quantity of water. Yield/production of leaf mainly depends on the production of primary branches to more number of primary branches can be produced from these buried nodes.

Vine is lowered to make convenient harvesting. If lowering is not done, vine goes to top, under such conditions ladder is required to harvest. Preferably lowering should be done during

spring season. Lowering can be done and once in a year in A.P. during March-May. It can be done 2 times in Cuddapah. (June-July and December).

Irrigation :

Requires high quality of water. Soil must be moist and water should not stand in beds not more than half an hour. Drainage must be perfect. Otherwise decay of roots resulting defoliation. Frequent light irrigations are always advisable.

During monsoon – 8-10 days interval

During Winter 7-8 days interval

During Summer 3-4 days interval

In loamy soils, interval of irrigation is shorter compared to clay soils. Bed system requires more irrigation than the trench system. In low rainfall areas, more number of irrigations must be given. Less frequency of irrigation is given in full bearing vine. If excess irrigation at full ……

Manuring :

Application of organic manures like FYM, compost, sheep manure, river/tank silt and oil cakes like castor, fish meal to maintain high quality of crop.

I application	25-30 bags of groundnut cake applied during 2 months after planting (Nov-Dec) 100-120 cart loads of FYM-applied at 3 MAP
II application	100-120 cart loads of FYM-applied at 1 ½ MAP prior to I lowering (Aug)
III application	100 cart loads of river/tank silt for pressing of lowered vine-immediately after lowering
IV application	25-30 bags of GN cake + 50-75 bags neem cake/ha should be applied in II-year of plantation

II, III and IV applications must be repeated in III and IV years.

Intercultivation :

Weeding and hoeing must be done regularly. Keep the garden clean without dead/diseased vines. Clean the fallen leaves and leaves of standard. Provision must be made for drainage during rains. Earthing up should be done at regular interval particularly during manuring.

Intercropping :

Inter crops not grows. But in Nellore, turmeric or ginger is grown along the irrigation channels. In T.N., Gogu is ciliated. Coconut or groundnut plantations, belladonna is grown as intercrop.

Betelvine can be grown continuous upto 5-10 years, depletion of nutrients by the development of pests and diseases. Betelvine must be rotated with other crops. In A.P., turmeric, banana, sugarcane and veg.

Karnataka – Tobacco, chilli, wheat and jowar

Assam – No rotation is followed. After completion they leave the land fallow for 2 years.

Harvesting :

Under good management, leaves can be harvested 3-6 MAP of setts, possible in A.P., T.N., Maharashtra. Plantations retained for 3 or > 3 years. Harvesting continued daily/weekly depending on the demand. In other states, harvesting starts 1 year after planting and plantation retained for more than 3 years.

Types of leaves :

In betelvine, there are kinds of leaves.

1. Matured leaf (Tunawar/Bondaku) : Exported to destination. Leaves will be ready by the time they reach to the destination.
2. Tender leaves/tellaku : Harvested to meet the demand of local markets/
3. Rejected leaf/Pothiaku : Harvested damaging or over matured leaves.

Chemical composition of leaves :

Constitution	Fresh leaf (%)	Bleached leaf (%)
Non-reducing sugars	1.3	0.29
Reducing sugars	0.43	0.83
Tannins	2.05	1.89
Oil	1.23	4.20
Ether extract	15.1	13.5

Harvesting of leaf is skillful job. Leaf cut alongwith petiole and with the help of nail/artificial nail and fixed to thumb. 4-5 leaves are picked per vine. 2-3 leaves from newly established garden or vine. Young and olden garden gives less yield. Middle age garden gives higher yield and high quality.

Yield :

In A.P., Assam and Kerala the yield is 12-25 lakh leave/year/ha

In A.P., life span is 2-3 years

Karnataka : 10years

U.P., Maharashtra : 6-10 years.

Grading :

Grading is according to leaf size. In some areas, graded according to the position of the leaf on the vine.

3 important grades in the betelvine are

1. Angular (Kalli leaf) : Harvested from main stem; Inferior – medium quality

2. Hatwan (Krapaku) : Harvested from the lateral branches; excellent quality

3. Modern (Teegaku) : Harvested other than main or lateral branches, mostly on ponds, poor and inferior quality.

After grading, packed according to size or maturity. Bundled, tied in banana leaf or wet paddy stem. 100-200 leaves are in bundle. Bundles kept in bamboo basket with paddy stem as bedding material so that leaves are not day, basket covered with bamboo and stitched.

Middlemen are involved. Commission agents, wholesalers gather and collect the material from the farmer and sell to the retailer. At the time of transport, 30-70% leaf damage occurs if care is not taken. It takes 5-7 days to reach the consumer from the grower.

Bleaching of betelvine :

Specialized operation is followed in big cities done on small scale. Large quantity of leaf consumed as fresh small quantity is bleached.

Characters of bleached leaves :

- Contains medicinal value used in Ayurvedic medicine
- Recommended for chewing
- Contains more reducing sugars
- Essential oils are having more aroma and taste
- The oil strengthens the teeth

Selection of leaf to bleaching :

Collect healthy leaf from 3 years matured garden. Leves collected from the vine of 3 months old after loweing of vine. Select the grade of ..... or matured leaf, they will be tough and dark green.

Leaves are trimmed and removed the petiole.

Procedure : After trimming, the leaves are arranged spirally in bleaching chamber. Cylindrical G.I. open both sizes of 70-100 cm dia, 45 cm deep, 16,000-24,000 leaves can be accommodated. Dry banana leaves spread a the bottom to drain out excess water from leaves. Leaves are arranged 2-4 circular rings from periphery towards centre upto the brim.

A vertical column of clean space is left at the centre which helps in aeration. Tin is covered with moist gunny cloth kept in dark, well ventilated room. Summer bleaching takes place in 15 days, winter takes 15-20 days. At the end of bleaching, leaf attain uniform yellow

colour. During processing of bleaching, examine at every alternate day to remove the rotten leaves. Arrange the clear leaves and sprinkle the water to moist the leaves to lower the temperature in the chamber.

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COFFEE

(*Coffee orabica*)

F : Rubiaceae

Origin : Ethiopia

Non-alcoholic beverage or stimulant beverage.

Spread to India by Arabs (Bab a budan)

Introduced from Makka

Planted in Dattatreya peeta hills, Chikmaguluru district (Karnataka).

History :

In 1898 it is introduced in A.P. by Arab settlers. These settlers brought to Siricilla (Karimnagar),later introduced into Agency area (1920-1948). It came to commercial cultivation in 1960 due to forest department efforts; agency are of Visakha, Vijayanagaram and Srikakulam.

Coffee is grown in more than 70 countries. More than 50% of the world's area is confined to Brazil, Colombia and Ivory coast. In India it is confined to Kerala, Karnataka and Tamil Nadu. Later it is spread to non-traditional states like A.P., Assam, Orissa, Arunachal Pradesh and Nagaland. In A.P., Chintapally, Paderu, Maredupally, Sitampet, Araku valley, Anantagiri hills, Srikakulam and East Godavari districts. In India it is cultivated in 60% area (C.arabica). 40% is under C.conephora.

Uses :

- Non-alcoholic/stimulant beverage
- Good medicinal properties, gives comfort to brain, relieves from headache, litharge.

- Helps in digestion of food
- Coffee husk and coffee pulp is important byproducts. These are used as manures and fuel purposes and as a cattle feed.
- Alkaloid present is caffeine.

Botany :

It is evergreen perennial shrub. It produces two types of branches.

1. Orthotropic branches : Upright branches produces other ..... branches and lateral branches.
2. Plageotropic branches : These are the branches produce only lateral branches. Fruiting occurs on laterals. On decapitation or topping. It produces the primary branches, secondary and tertiary branches and develops the canopy. Secondary and tertiary branches bear the fertile flowers appear in clusters packed at the nodes (10-60).

Fruit in coffee is drupe having 2 seeds called beans. Exocarp is juicy. Endocarp covers is called as parchment cell. Seeds are present in endocarp.

Characters	Arabica	Robusta
Ploidy	Tetraploid (2n=44)	Diploid (2n=22)
Plant stature	Small tree, shrubs or bushy under raining	Bigger tree than Arabica
Root system	Small deep rooted	Large shallow rooted
Branches	Persistent	Deciduous after harvest
Leaves	Dark green leaves	Pale green leaves
Flowering habitat	Flowers on new wood	On new/old wood
Bearing	Regular bearer	Irregular bearer
Flowers	Scaly, small traits, axillay, 4-5 inflorescences at each node	

Pollination	Self fertile/self pollinated	Self sterile/cross pollinated
Berries	Medium in size, 10-20/node, oblong to round shaped	Small, 40-60/node
Fruit dept.	8-9 months	10-11 months
	2.47%	2.2%

Climate :

Majority exist in tropics 28^0N and 30^0S latitude. It is highly sensitive to frost. Water stress is essential to break the dormancy. Cold winter is favourable for flower bud initiation. After cool, winter it should be coupled with rains and high temperatures stimulates flowering and easily fruit setting.

Winds at the time of flowering affect the fruit set, high winds beak the branches so protect by raining the wind breaks. Hill slopes are very suitable. Well distributed rainfall and dry months during December-March is preferred. Summer showers will encourage flowering climatic requirement differ in Arabica and Robusta.

Parameter	Arabica	Robusta
Climate	Temperate climate in tropics	Warm humid
Elevation	900-1500 m	500-1000 m
Annual rainfall	1600-3000 mm	1000-2000 mm
Temperature	15-35^{0}C	29-30^{0}C
RH	70-80%	80-89%
Shade	Med-light shade based on elevation	Uniform thin shade

Direction	North, east and north-east	
Slope	Flat to gentle	Flat to gentle slope
Blossom rains	March-April	February-March
Back rains	April-May	Aplir-May

Soils :

Average fertile soils. Physical properties like depth, drainage, aeration are important requirements (Arabica). Humus rich soil in tropical region. pH should be between 4.2-6.5. it can be grown on hill slopes and undulating topography. Best soils should e in rich in humus. Deep soils, friable, porous with good water holding capacity, rich in K, slightly acidic, pH of 6-6.5 can be used. In India, mostly red and lateritic soils are generally used.

Land preparation :

It needs shade so removal of vegetation is not required. Retention of certainplants which provide shade is required by repeated ploughing, make it loose and friable. Inlarger areas,it can be divided into different blocks and rows. If land is sloppy, terracing or contour bunding canbe followed. Coffee planted in square system of planting.

Spacing :

For Arabica : 2-2.5 m

Robusta : 2.5-4 m.

Digging of pits : (45-60 cm3) pits left for weathering. Pits filled up with top soil and forest soil in equal proportions go for disease free, vigorous rooted cuttings. After planting watering and stalling must be done.

Provision of shade : It is important as it requires partial shade where sun light is intense to maintain moisture and temperature of the soil. Shade consists lower and upper canopy. Lower canopy is temporary. Ex : ..... following a spacing of 4x4 m. Silver oak is also used but it should be pruned and lopped.

Upper canopy : It is permanent basis.

Ex : Alberria lebeck, Artocarpus integifolia, Dalbergia latifolia, Ficus glomeralo with spacing of ……. at the time of planting, thick sowing must be done later thinning should be done. It should be maintained 40-44 m above the coffee. Shade tree pruned and lopped.

Manuring :

It is a perennial. S nutrients required for protection of matured fruits to encourage fresh growth, as it requires for production of next growth. In heavy rainfall, sloppy areas, nutrients loss is due to rains and leaching. Flowering, fruiting are in pH peak periods for manuring.

Manuring schedule (kg/ha) :

Time of application or age of plant	Pre blossom	Post blossom	Mid monsoon	Post monsoon	Total
Arabica					
Young coffee	15-10-15	15-10-15	-	15-10-15	45-30-45
I-AFP					
II-AFP	20-15-20	20-15-20		20-15-20	60-45-60
IV-AFP	40-20-40 40-30-40	40-30-40	40-30-40	40-30-40	140-90-120
Bearing coffee (yield t/ha)	40-30-90	40-30-40	40-30-40	40-30-40	160-120-160
Robusta					
Bearing pt	40-30-40			40-30-40	80-60-80
Bearing	40-30-40	40-30-40		40-30-40	80-60-80

High level moisture must be provided by mulching, cove roping and also by pruning the shade trees.

Irrigation : Grown as rainfed crop. For young plantations, sprinklers a\re used.

Intercropping :

Intercrops are growing along the perennial crops like coconut. Robusta planted by 2.5x2.5 spacing in triangular system. 2 rows of coffee in between 2 rows of coconut.

Arabica grown 2x2 m, 3 rows are planted …….. two rows of coconut. Tea can also be grown as intercrop. In Mandarian oranges, coffee can be grown as intercrop.

Soil management :

Conserves the soil moisture by scuffling. Soil stirring (dry mulch) to control weeds and moisture conservation. Mulching done in basins to conserve soil moisture to maintain optimum temperature, effective to control the erosion.

Weed control :

Crop should be free from weed y weeding 3-4 times. In established gardens 2-3 times/year. In monsoon, weeds can be controlled by slicing. Cut weeds at the end of rainy season. Gramanone is used @ 1.25 lit/450 lit water.

Liming :

Liming in heavy rainfall areas Co, Mg will leached. Soil acidity will increases. Usage of acid forming fertilizers will increase the acidity of soil. Acidity will have ill effects on the availability of nutrients to liming must be done.

Dolomite lime/agriculture lime are used. This applied at any time but maintain 1 month gap between liming, fertilizer application. Sufficient moisture must be maintained.

Cropping :

It comes to bearing 3 YAP. 5-6 YAP is commercial level.

Productive life : 30-50years.

Harvesting :

C.arabica comes to harvest earlier than robusta. Arabica takes 8-9 months and ready for harvesting during Nov-Dec. robusta takes 10-11 months.

Harvesting is done by hand. Riped berries hand picked. All berries do not ripe at area So number of pickings will be more may be 5-6 pickings. Injured over riped fruits kept separately, dried separately used for making cherry coffee.

Types of picking in coffee :

Fly picking : I-picking in main season. It is selective picking during Oct-Feb. riped berries are collected.

Main picking : Bulk yields are obtained. Well developed, fully riped berries are harvested 4-6 times at 10-15 days interval, started from December onwards.

Stripping : it is the final harvest and all the left over berries on plant harvested irrespective of ripening.

Clearing : It is the collection of dropped berried from the plant.

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MEDICINAL AND AROMATIC PLANTS

Common name	Botanical name	Family	Economic part
Medicinal			
Dioscoea	Dioscorea compositae	Dioscoreaceae	Tuber
Opium poppy	Paper somnifer	Apocyanaceae	Root
Sarpagandhi	Rauvolfia serpentine	Solanaceae	Bark
Solanum	Solanum kharianum		
Nuxvomica	Strychrus		Seed, root, bark

	nuxvomica	
Aromatic		
Palmarosa	Cymbopogon maitinii	Poaceae
Citronella	C,wubteruabuu	Poaceae

Advantages :

- Generate employment through the development of ancillary industries.
- High net returns compared to Agricultural crops.
- Foreign exchange through exports.
- Efficient utilization of …….. forces.
- Longer shelf life of end products
- Low incidence of pests and diseases.
- Crops can be grown in degraded and marginal problematic soils.
- Crops are theft proof.
- Crops not eaten by the domestic animals.
- Crops not damaged by the birds/
- Used in crude form (fresh juice, paste) but now used as decoratives, herbal teas and tablets, distillers.

Disadvantages :

- Indiscriminate harvest from wild leading to some plant ….. becoming extinct.
- Short supply of quality and raw materials.
- High price, short supply leading to adulterations.
- Unstable supply, unreliable botanical identification.
- Poor post harvest handling.

Institutions :

CPCRI	-	Central plantation crops research institution – Kesarghood, Kerala
IISR	-	Indian institute of spice research, Calicut
CFTRI	-	Central food technology research institute, Mysore

DCASD	-	Directorate of Cacao, arecanut and spices development
BIS	-	Bureau of Indian standards
ISO	-	International organization of standardization, Budapest, Hungary
CIMAP	-	Central institute for medicinal and aromatic plants, Lucknow, Bangalore and Hyderabad
AICIPS	-	All India co-ordinated improvement project, Kesarghood, Kerala
Spices board	-	Cochin (Ministry of commerce)
Cardamom		
CRS	-	Cardamom research institute, Pampadumpara, Kerala Agricutlural Colelge
BRS	-	Regional research station, Mudigore, University of Agricultural sciences – Karnataka
HRS	-	Horticultural research station – TNAU
Black pepper		
PRS	-	Pepper research station, …….. KAU, Kerla
PRS	-	Pepper research station, Chintapally, APHU, A.P.
PRS	-	Sirsi, UAS, Karnataka
Ginger and Turmeric		
HARS	-	High altitude research station, Pottangi, Orissa University of agricultural technology (OUAT), ICAR
DVCF	-	Department of vegetable ropos and floriculture, Solan, H.P. Agriculrura College, College of Horticulture, Vellanikkara, KAU, Kerala
Seed spices		
DSPC	-	Department of spices and plantation crops, Coimbatore, TNAU, Tamil Nadu
PARS	-	Regional agricultural research station, Lam, Guntur, A.P.

ARS	-	Agricultural research station, Jagudam, GAU, Gujarat
NBPGR	-	National bureau of plant genetic resources, New Delhi
MAPR	-	Medicinal and aromatic plant research station, Odakkali, Kerala

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AROMATIC PLANTS

Aromatic plants are those possess essential oils in one or more plant parts.

Plant	**Part used**
Vettiver	Root
Sandal wood	Wood
Cassia	Bark
Geranium, Citronella	Foliage
Lemon grass	Foliage
Jasmine	Flower
Citrus	Fruit
Coriander	Seed

Essential oils : Present in oil glands.

- Essential oils have the smell or they are the complex mixture of odoriferous, steam, volatile.
- These are compounds deposited by plants in subcuticular spaces of granular air spaces or cell organelle/excretory cavity, canals especially in hard wood plants like sandalwood and red sanders.
- They do not have any specific functions in plant but when they come in contact with air, they evaporate and give pleasant fragrance. The main purpose is to attract the pollinating agents and repel the pests and animals and other natural enemies to avoid the damage.

- They give competitive advantages to producer plant and inhibit the growth of competitions to plants like needs.

Uses :

- To improve the flavour and food.
- Add flavour to industrial important products like spices, lemon grass, citronella oils, used in soaps, agarbattis, cosmetics, perfumery industry.
- Impart desirable smell to above products which used in drug and pharmaceutical industries manufacturing of pesticides, germicides, disinfectants due to their centrifugal, antiseptic and insecticidal properties.
- Used as laboratory reagents, solvents in paint industries.
- Important component of polishes.
- Left over material after extraction of essential oils used for manufacturing of card board, cheep paper and also used as packing material.
- Also used as fuel for distillation of aromatic plants.

Essential oils industry in India :

- Very old cottage industry in India.
- India is traditional producer of essential oils like palmanosa, lemon grass
- India is exporting these essential oils to other countries.
- Indians have habit of using essential oils in rituals, holy functions, religious ceremonies, agarbattis
- Aromatic plants placed in Indian medicine. Ex : Sandal wood, tulsi, mint.
- Distillation of essential oils is first Practiced in India. Ex : Distillation of rose flowers mentioned in Charaka Samhita and Sushruta.
- Moghul emperors used perfumes like Attar have been popularised since that time only exports are started.

Commercialization of crops is lagging because;

- Though agro climatic conditions are suitable, they have not achieved stron putting because farmers lack profitability of essential oils. Lack of marketing facility at farmers level.
- High initial investment for establishment of equipment and installation of distillation unit.
- Lack of availability of planting material.
- Price fluctuations due to changes in the world's supply and demand.
- Aromatic crops face competition for land from food crops.
- Lack of scientific knowledge about cultivation.
- Occurrence of diseases like spike diseases in sandalwood, fusarium disease n geranium
- No organised efforts to collect and maintenance of germplasms of essential oils bearing plants.
- Produce is priced/market value based on the presence of active principles in the crop.
- It is a risk element
- Attitude and demand of industries to have location purchase points at limited places is not materialized causing out off reach to the rural farmers.
- Lack of testing labs for essential oils, cheaper synthetics and substitutes are available in the market.
- Lack of trained persons in the field of medicinal and aromatic plants.

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LEMON GRASS

(*Cymbopogan flaxuosus*)

F : Poaceae.

Origin : India

Cultivation is started 100 years back in Kerala. It attained plantation stage in Kerala in 100 years back.

Other countries : Haiti, Gautemala, West Indies.

Lemongrass oil is known as Cochin oil. Cultivated bulk in Kerala and J and K.

Annual production in India is 1000 MT. competition is from Gautemala

Uses :

- Important constituent is citroll/geraniol.
- Citral is used for manufacturing of Vit-A tablets.
- Oil has bactericidal, insecticidal and insecticidal, medicinal values.
- Oil is essentially used in soaps and detergents making.
- Spent grass act as cattle feed and can be converted into good silage.
- Used in manufacturing of card boards and paper and fuel

Species :

1. East Indian Lemon grass – *C.fleruosus*

Indigenous to Kerala

Grown in Kerala and near by states.

Oil is popular as Cochin oil, shipped through Cochin sea port.

2. West-Indian Lemon grass – *C.citratus*

Cultivated in Gautemala, Haiti and West Indies.

3. Jammu Lemon grass – *C.pendulus*

Resistant to frost

Growth period of crop is 8-9 months/year

Dormancy in between December-February

Cultivated in Jammu, Kangar valley (Palmapur)

Climate :

It is tropical plant requires hot humid weather, requires plenty sun light. Rainfall is 150-300 cm, uniformly distributed, mainly grown as rainfed crops.

Soils :

It is a hardy and drought resistant plant. Loam to poor lateritic soils, hilly slopes, marginal soils can be used. Ideal pH is 4.5-7.5, grown as vegetative cover in sloppy areas to control the soil erosion.

Propagation :

Propagated by seeds and slips

Clumps will be taken and separated as slips, cutted and used.

Time of planting :

Land should be ploughed thoroughly, layed out into ridges and ferons. Rooted slis and seedlings planted with onset of rains favouring the spacing of 60x45 cm.

2-3 slips/hill.

Manures :

FYM-10t/ha applied during last ploughing. General recommendation : 100-50-50 NPK/kg/ha.

P & K – Basal and

N – IN 3 splits

I split @ 30 DAP

II & III after each harvest

Irrigation :

Irrigation is not required when it is grown in high rainfall areas. In low rainfall areas, give irrigations at 10-12 days interval.

Weeding :

Maintain weed free upto 3-4 months. Plants should be earthened up after every weeding.

Harvesting :

I – harvesting : 5-6 months or 150-180 DAP

Comes early in Kerala; 90-100 DAP.

Subsequent cuttings after 3-4 months.

Grass is cut 10-15 cm above the ground level.

Delayed/early harvesting must be avoided as it effect the citedal content.

If any flower stalks observed in the field, they must …….. as it effects …….

During first year, 3 cuttings can take up

From second year 5-6 cuttings

Maximum yield obtains between 2-4 years

Plantation can be economic upto 5-6 years

Yield :

Herbage yield – 15 t/ha

After cutting, essential oils extracted by steam.

Distillation - ……Oil yield is 80-100 kg/ha **000**

CITRONELLA

(*Cymbopogon winterianii*)

F : Poaceae

Also known as Java citronella

Ceylone citrenll : *C.nardus*

Origin : Srilanka

Java citronella	Ceylone Citronella
Superior in oil	Inferior in oil
Alcohol 90-99%	Alcohol 60-70%

Active principle : Citronellol, Citronellal and Geraniol

Uses :

Used in soap, perfumery, cosmetics, flavouring industry

Hydroxyl citronellal is prepared from Citronella oil, most frequently used in flavouring perfumes

It is important mosquito repellent. Used in oils and mosquito repellent creams

It is cultivated in Germany, China, and Java. Other important countries are USA, UK, France, Japan, Hongkong. In India it is cultivated in Assam in tea gardens, Karnataka, T.N., A.P., U.P., Gujarat and Maharashtra. To some extent is Arunachal Pradesh, Mysore, Meghalaya, Nagaland and Tripura.

In India it is cultivated in 4500 ha area, giving 500 t of oil/year. In A.P., it is cultivated in Visakha, East Godavari, in an area of 750-1000 acres.

Climate :

Tropical and sub tropical climate is required. Requires abundant moisture and sun shine of 200-250 cm. high humidity is required as it influence the plant growth, yield and quality of oil.

In low rainfall areas – Irrigated crop.

Soils :

Sandy loam soils with abundant ……. is suitable. Soil pH is 5.6-8.0. pH = 6 in ideal. Grown in altitudes between 1000-1500 m above MSL.

Land preparation : Refer lemon grass

Beds of 6x6 m size. Prepare R&F by furrows at a spacing of 60 cm apart with a provision for irrigation channels.

Planting and propagation :

Propagated by seeds and slips – Refer record

Best time for planting slips in June-July. In A.P., July-August, slips planted with a spacing of 60 x 60 cm. seed rate is 22,000 slips/ha. in high fertile soils, in Assam spacing is 90x90 cm. slips should be planted on ridges to avoid water logging conditions. It takes 3-4 weeks for establishment.

Manures and fertilizers :

10 t FYM/ha - @ last ploughing

(800120) – 80-40 NPK kg/ha

P & K – Basal application and N – 4 to 5 splits (equal)

I split @ 30 DAP

II to V splits after each harvesting

In North India, follows 5 splits

South India 4 splits

CIMAL recommended 0.5% Fe through FeSO4 and …… which helps in checking the chlorosis.

Irrigation :

Sufficient moisture is essential for good growth. In high rainfall areas, no need of many irrigations but dry areas require 10-12 irrigations.

Overall 16-20 irrigations/year, frequently 7-10 days

Weeding :

Maintain weed free crop

After each harvest, weed out the field by manually or mechanically.

Harvesting :

I harvesting 9 MAP by using sickle.

Cut 20-45 cm above ground level.

In Karnataka harvested during March, June and September

Crop comes to maturity in October-November. Flowers mst be discouraed. If flower stalks are observed they should be knipped out otherwise life span will be reduced. It keeps the crop economically for 3-4 years.

After harvest, sent immediately for distillation – Refer record

Yield :

Herbage yield : 15-20 t/ha – I year

Oil yield : 100-150 kg/ha - II year

II year : Herbage yield 20-25 t/ha

Oil yield : 200-250 kg/ha

After 3-4 years, replace with the new crop.

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PALMA ROSA

(*Cymbopogon martinil*)

F : Poaceae

Also called as Rusa/rusha grass

Oil called as 'Rusha oil'

Origin : Sub tropical India.

Important constituent is Geranial.

Palma rosa yielding high geranial content (70-75%). Oil is also called as East-Indian Geranium oil or Rusa oil.

Uses :

- Uses in perfume industry
- For flavouring tobacco and blending of soaps.
- Source for high grade geraniol
- Starting material for synthetic aromatic chemicals
- Geranyl esters giving rose odour

Soils :

Well drained loamy soils with pH 6-7. if pH is greater than 8.5, it will decrease the growth of plants and oil yield but quality of oil will not change. Provide good drainage.

Climate :

It comes up well in warm tropical climate. Elevation is 300 m, temperature is 36^0C, relative humidity is 150 cm. requires good sunshine. Frost areas are not suitable as plant kills the grass to reduce the oil content.

Land preparation :

Plough and hallowed till fine tilth is obtained.

Remove the stubbles and roots. At last ploughing, apply 10 t FYM.

It is propagated by seeds and slips – refer record.

Plant the seedlings 10-15 cm of 60x60 cm of spacing. Plant is well prepared beds in rainy season.

Manures and fertilizers :

No manuring is required in rich soils during 1-2 years. In deficit and poor soils, apply 20-50-40 kg NPK/ha. 40 kg N/ha must be applied in 3 splits additionally after each harvest to encourage the growth.

Weeding :

Flavour is important quality so essential oils to keep the field weed free, specially weeds having odour. Regular weeding is done. Care should be taken. Apply weedicide dichlom @ 1.5 kg/ha.

Harvesting :

Essential oil is distributed in all parts of plant. But flower head contain more quantity. Grass harvested when attain 4 months. Grass is cut 5-8 cm from the ground level. Whole plant is sent to distillation. Maximum oil can be obtained when field is in full flowering stage.

I year : First harvesting – One crop : Oct-Nov; II year : 2-3 harvestings can be taken

It is productive for 8 years. High oil yield upto IV year and later oil content decreases. So we can keep for 4 years. Oil is extracted by steam distillation method. – Refer record.

Yield :

Plant part	**Oil %**
Whole plant	0.1-0.4
Stalks	0.01-0.03
Flowering heads	0.45-0.52
Leaves	0.16-0.25

Rainfed crop :

I year	20 kg oil/ha
II year	60 kg/ha
III year	70 kg/ha
IV year	70 kg/ha

Irrigated crop :

I year	200-250 kg/ha

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GERANIUM

(*Pelargonium groveolens*)

F : Geraniaceae

Also called as Rose geranium/Paneer patra

Origin : South Africa

Active principle : Citronellal/Geranial

Geranium is of two types

1. Rose Geranium : Yields C
2. Ornamental Geranium N

Oil itself is a perfume and blends with other perfume used for scenting the soaps

Used for isolation of 'Rodinal' which is the high grade perfume

India importing > 20 tonnes of oil/year

Soils :

Performing well in red lateritic soils with pH of 5.5-8.0. calcium rich porous soils are best suited.

Climate :

Requires temperate, tropical and sub tropical climate. 1000-2200 m above MSL, temperature 5-23^{0}C. if temperature is <3^{0}C, it kills the plant. Best climate is warm winter coupled with mild summer. Rainfall 100-150 water logging causes root rot and stunted growth. Grows n lower altitudes also. Tolerate a temperature of 43^{0}C.

Land preparation : Foam R & F with a spacing of 60x60 cm.

Seed rate : 28000-30000 rooted cuttings.

Irrigation :

Initially growth is very slow, later on growth picks up. Alternate days in the beginning of 10-15 days, later twice is a week.

During winter and summer, 7-10 days interval. Water logging must be avoided.

Weeding :

Weeding should be done periodically. Crop should be weed free in initial stages. It is intercropped with cowpea/blackgram.

Apply 10 t FYM @ last ploughing

35-35-35 NPK kg/ha

N – Urea; P-MOP; K-Super phosphate

Further N should be applied at each harvest

Total of 210 kg of N/ha/year

Zn is applied @ 20 kg as $ZnSO_4$

Boron W 10 kg/ha

Harvesting :

Comes to harvesting @ 4 MAP.

Harvesting indices : Leaves turn light green colour

Odour changes from lemon odour to rose odour

By using sharp sickles, harvest 3 crops/year

Crop is economic for 3-6 years

Oil content is high during summer, April-June

Terminal portion of 6-12 leaves contain more oil when compared to basal and medium leaves

Yield :

Herbage yield : 30-40 t/ha/year

Oil yield : 15 kg/ha/year

Oil content : 0.08-0.15%

Oil is extracted by steam distillation - Refer Record.

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VETTIVER/KHUS

(*Vettiveria zizanoides*)

F : Poaceae

Origin : India

Also known as Khus-Khus/Aromatic root

Active principle : Vettivom and Vetirerone

Active principle vary in spices in some species *i.e.,* khusal and khusone

Vettiver is densely tufted with rough leaf, perennial grass, grown in different types of soils.

Economic part : It is underground root contain fine rootlets of light yellow or grayish to red colour depending on soil type. They contain aromatic viscous essential oil. Oil can be obtained by distillation method.

In the world, it is grown in India, Burma, Srilanka. In India; Kerala, T.N., U.P. and Rajasthan.

Uses :

- Fans are prepared
- Hanging curtain are prepared
- Used for s…….. the clothes by using sachet
- Making of baskets, mats
- When sprinkled with water gives cool air and emits pleasant odour
- I is important material for preparation of perfumes, cosmetics and soaps
- It also blends with other oils like sandalwood, rose oil
- It has medicinal value, acts as good stimulant, oil is used for relieving from body pains
- Tender leaves are used as fodder, for thatching purpose
- Inflorescence used for making brooms and ornamental baskets
- It is the best soil binder and controls soil erosion extremely in arid zone

Climate :

Requires moderate humidity and temperature of 21-44^{0}C. it is a tropical and sub tropical plant grows luxuriantly with annual rainfall of 1000-2000 m above MSL.

Soils :

Comes up well in al types. Light soils must be avoided and therefore gives less per cent of oil. Sandyloams to red lateritic soils which are rich in ..... having good drainage are ideal. Grows well in saline, alkaline soils with pH of 8.5-10.

Land preparation :

Plough upto depth of 20-15 cm repeatedly. During last ploughing apply FYM. Make R & F's and ..... of 10x10 cm plot size.

Propagation : Refer Record

Propagated by tillers and slips. Tillers take longer time to grow so slips are used. Slips are collected from previous crop.

Planting :

During June-July with onset of rains 2-3 slips/hill at a depth of 5-8 cm with a spacing of 45x30 cm.

Population required is 1.5-2.25 lakh slips/ha. after planting, give irrigation till the establishment.

Manures and fertilizers :

- FYM at 10 t/ha during last ploughing
- 25-25-25 NPK kg/ha, entire P and 1/2 N @ planting 1/2 N after 6 MAE
- 60-23-23 kg NPK/ha for Kerala region

Weeding :

- It must be done during new plantation.
- 3-4 weedings are required
- Once plantation is established, weeds are not a problem

Harvesting :

Root ready for harvesting after 18 months. Roots will be hard, skin will be peeled out easily. At this stage, they give bitter taste but have high per cent of oil.

Oil derived from very old root, is dark in colour. Harvesting must be done during rainy season because oil is easily diffuse from roots into soil. Therefore, decrease in oil content during this period when rain occurs, plant star giving new roots and synthesis of oil gets reduced.

Herbage portion is cut at a height of 15-20 cm above the ground. Dumps can be uprooted by digging roots can be separated and washed with water and dry under shade for about 1-2 days and sent for distribution of oil. Roots should not dry in sun, as oil will decrease.

Yield :

3-4 t/ha - Root yield

In NI, 14-18 t/ha

Oil percentage is 1%

Oil yield is 15-16 kg/ha.

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DAVANA

(*Artemesia pallens*)

F : Arteraceae

Origin : Himalayan region

Active principle : Cis davanone

Uses :

Davaria is a annual aromatic herb valued for the delicate fragrance.

Oil content cost 15,000-18,000 Rs/kg

Tender shoots can be used in making garland, religious functions and ceremonies, high grade perfumes and cosmetics.

Oil contents : Hydrocarbons – 20%

Esters – 65% (odour)

Oxygenated compounds – 15%

In countries like USA, Japan used as flavouring of cakes, pastries, tobacco and beverages

Alkaloids contain are DAvana fuaris and Artemones

India is the only country cultivating Davana mainly in Karnataka and A.P.

In A.P.; Krishna, Cuddapah, Chittoor and Guntur districts.

Soils :

Sandy loams to medium black soils are the best soils. Fertile, well drained soils which are rich in O.M. are best suited.

Winter is the best reason for Davana growing as it gives high per cent of oil.

It requires bright sun shine, moderate rainfall, temperature 20-30^{0}C.

Planting :

Planted during first week of November for oil purpose as main crop. Ratoon crop taken upto April. High temperature, heavy rains at the time of flowering affects plant growth and reduces oil content leading to lone yield. Davana is propagated by seed; seedlings raised in beds. After 6-8 weeks when plant attains 10 cm, transfer to main plots.

Plot size is 3-4 x 1.5- 2m. Beds irrigated one day in advance. Transplant the seedlings with spacing of 15x7.5 cm. immediately give another light irrigation. Irrigated daily for 10 days and then alternate days.

Manures and fertilizers :

FYM @ 6 t/ha 2 last ploughing

120-40-40 kg/ha

P & K as basal, N in 3 equal split doses

I dose @ 10 DAP

II dose @ 25 DAP

II dose @ 40 DAP To encourage the herbage

Irrigation :

Give continuous irrigation upto 10 days and then alternate days; depending on the weather give a 4-5 days interval.

Maintain weed free crop. Requires 2-3 hand weedings during early period of growth.

Harvesting :

It should be done when reaching to 50% of flowering to get maximum yield.

Starts flowering 110-115 DAP; 50% flowering 120 DAP

Cut the plants at the base leaving stumps of 10 cm. again fresh growth appears. Ratoon crop can be taken up 2 months after first cutting, after crop is removed.

Yield :

Herbage yield is 10 t/ha

Oil yield is 10 kg/ha.

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MEDICINAL PLANTS

ACORUS
(Sweet Flag)

S. name *Acorus calamus*

Family – Aeraceae

- ✓ Dried root (rhizome) – medicinal preparation flavouring liquors.
- ✓ Contains volatile – yellowish brown oil – pleasant – slightly sweet odour – steam distillation
- ✓ Calamus oil – composition – source of rhizomes
- ✓ Plant aromatic – Acorin
- ✓ Expectorant action – remedy for asthma
- ✓ Remedy – chronic diarrhoea

- ✓ Bach – prepared from rhizomes – medicinal properties

Botany

- ➢ Monocot plant – herb – narrow leaves
- ➢ Economic part – rhizome – horizontal – jointed – spongy texture – 1.5 – 2.5 cm thick

Species/Varieties

- ✓ *Acorus gramineus* – Japanese species
- ✓ *Acorus Calamus* – India and Srilanka

Soil

- ✓ Same way as rice – irrigation facilities
- ✓ Good and moist soil
- ✓ Clayey loam soil – light alluvial soils of river bank

Climate

- ✓ Hardy plant – tropical to subtropical climates
- ✓ Good-well distributed rainfall throughout year

Planting Season

- ✓ Best season March-April – Any time of year
- ✓ Plenty of sunshine – harvest –dry rhizomes

Propagation

- ✓ Live ends or tops of previous crop
- ✓ At harvest- mature portion of rhizome cut off for markable part
- ✓ Tender portion of growing and replanting
- ✓ Storage for one week- covering with straw or dried leaves
- ✓ Longer Keeping in open pits

Planting

- ✓ Recommended spacing 30 x 30 cm
- ✓ Rhizome pieces presses into mud – 5cm depth
- ✓ Rhizomes planted – plant in second row – between first row not opposite to it

Manures and Fertilizers

- ✓ Manured with green manure (10-12 t) – compest 15 t ha^{-1}
- ✓ 125 kg NPK/ha – 3 splits

Irrigation

- ✓ Regularly irrigated
- ✓ 5 cm water left standing is field – increased 10cm as plant grows

Harvesting and Yield

- ✓ After year – crop ready for harvesting
- ✓ Field partially dried-sufficient moisture – necessary deep digging
- ✓ Leaves turn yellow, dry-indicative of maturity

- ✓ Rhizomes depth 60 cm – 30-60 cm long- harvesting carefully
- ✓ Rhizomes cut into short lengths 5-7.5 cm – fibrous roots removed
- ✓ Pieces are washed – dried in sun
- ✓ Dried material in gunny- rubbed to free ocales
- ✓ Fresh aerial parts – 0.125% oil
- ✓ Yield 10 t ha^{-1}
- ✓ Indian roots – plains 3.1 % oil
- ✓ Kashmir valley not more than 1.4% of oil.

ALOE

S. name *Aloe vera and Aloe barbadensis*

Family – Liliaceae

Active Principles: Barbaloin

Origin: Eastern and Southern Africa

- ✓ Three important species A. barbadensis, Aloe vera (Curacao aloe, Indian aloe, Jaffarabad aloe or Barbadosalog and A. Perryi (scrotine aloe)
- ✓ Aloe – cutting leaves at base – let yellow bitter juice
- ✓ On heat – yield dark brown mass – drug aloe
- ✓ Two major products from leaves – yellow bitter juice specialized cells – beneath epidermis – yield drug aloe.
- ✓ Parrenchyma tissue – centre of leaf – mucilaging gel – yield aloe gel – obtained from A.barbdensis
- ✓ Anthro glycosides – Barbaloin – 4.5 to 25% aloin
- ✓ Other aloesin
- ✓ Aloe gel contain – gluco mannan – polysaccharide similar to guar
- ✓ Called burn, first aid or medicinal plant
- ✓ Laxative preparations
- ✓ Various cosmetics and pharma formulations.

Botany

- ✓ Coarse looking – perennial – shallow rooted- does not have true stem
- ✓ Multiple tuberous roots
- ✓ Male sterile- does not produce many viable Seeds

Species and Varieties

- ✓ Aloe vera var chinensis, and common

Soil

- ✓ Hardy grown on variety of soils
- ✓ Does well – sandy coastal – loamy soils – pH upto 8.5
- ✓ Water logged and problem soils not suitable

Climate

- ✓ Cultivated between March and June
- ✓ Wide adaptability – through out country
- ✓ Warm humid dry climate
- ✓ 150-200 cm to 35-40 cm yearly rainfall
- ✓ Dry region – protective irrigation

Propagation

- ✓ Root suckers or rhizome cuttings

Planting

- ✓ Spacing 60 x 30 cm or 60 x 45 cm
- ✓ 15-18 cm long root suckers – rhizome cuttings
- ✓ 2/3 portion under the ground

Manuring

- ✓ 150 kg/ha mixture of NPK

Irrigation

- ✓ After planting – one irrigation
- ✓ 4 to 5 irrigations / year
- ✓ No stagnation of water

Harvesting and Yield

- ✓ Eight months after planting
- ✓ Plants removed by manually or with tractor
- ✓ Broken rhizomes left in soil – succeeding crop
- ✓ Commercial yield from second – upto five years
- ✓ Fresh weight 10000 – 12000 kg/ha
- ✓ Chemically evaluated for aloin content and aloe gel.

AONLA

S. name : *Emblica Officinalis*

Phyllanthus emblica

Family : *Euphorbiaceae*

- ✓ Very rich in vitamin C medicinal and Ayurvedic
- ✓ Contain tannin – gallic acid, allagic acid, glucose in its molecules – retands oxidation of vitamin –C antisaorbustic in fresh and dried fruits
- ✓ Fruits useful in haemorrhaeges, dysentery, anaemia, jaundice, dyspepsia and cough
- ✓ Important in – Triphala – chavanaprash
- ✓ Used for preserve
- ✓ Great health vitality restorer

Botany

- ✓ Tree of medium height evergreen in tropics but deciduous in subtropics
- ✓ Phyllanthoid branching
- ✓ Flowers is axils of leaves – determinate shoots

Varieties

- ✓ Banarasi, chakaiya, kanchan, Krishna NA6, NA7, NA10, BSR-1, Anand-1, Sanshagold, francis

Soil and Climate

- ✓ Grows well in sandy loam to clay loam
- ✓ Tolerance to salinity and sodicity – pH 6-8
- ✓ Prefers subtropical – distinct winter and summer

Propagation

- ✓ Budding, grafting and seed

Planting

- ✓ Beginning of monsoon
- ✓ 8 to 10 m both ways
- ✓ 1 m pits
- ✓ After first rain plants are planted

Pruning

- ✓ Does not require much pruning
- ✓ Pruning early – proper shape – strong frame work – single stem – 1m height – primary branches regular spaces

Fertilizers

- ✓ Hardy stand well against drought
- ✓ Benefit – two irrigations at flowering and fruit set
- ✓ During summer – dormant

Intercropping

- ✓ Fast growing – initial – 3-4 years
- ✓ During summer dormant – only rainy season intercrops can be grown

Harvesting

- ✓ Vegetatively propagated – 6-8 years
- ✓ Seedlings – 10-12 years
- ✓ Productive life – 50-60 years
- ✓ Fruits – November /December
- ✓ Maturity – change of seed colour from creamy, white to black or translucent exocarp
- ✓ Maximum vitamin-C- mature fruits
- ✓ 60 to 70 kg fruits/tree
- ✓ 5 t /ha 20 t /ha^{-1}

ASHWAGANDHA

S. name : *W. Somnifera*

Family : *Solanaceae*

English name: Winter cherry

- ✓ Several alkaloids – withanine and somniferine are important
- ✓ Total alkaloid content in roots of Indian type 0.13-0.31%
- ✓ Used in ayurvedic and unani preparations

- ✓ Withaferine-A-antibiotic and antitumer properties
- ✓ Paste from leaves – curing inflammation of tubercular glands
- ✓ Roots skin diseases bronchitis and ulcers
- ✓ Roots- general and sexual debility
- ✓ Fruits and seeds –diuretic in nature
- ✓ Fruits and seeds – chest complaints
- ✓ Commercial drug – dried roots- small pieces 10-17.5 cm long and 6.12 mm in diameter
- ✓ Fruit is berry – turn orange red when mature

Varieties

- ✓ Jawahar asgandha -20- JNKVV mandsur

Soil

- ✓ Sandy loam or light red soils – good organic matter
- ✓ Easy to dig roots in this condition
- ✓ pH 7.5-8

Climate

- ✓ Subtropical climate
- ✓ Planted in rainy season – prefer dry weather
- ✓ 1-2 winter rains –roots to develop fully

Propagation

- ✓ Directly sowing the seed
- ✓ Raising seedlings

Direct sowing

- ✓ Seeds – directly – broadcasting
- ✓ Rainfed crop
- ✓ Monsoon – convenient size beds – second week of July
- ✓ Seed rate 10-12 kg/ha

Nursery raising and planting

- ✓ Seedlings are raised – raised nursery bed
- ✓ 5 kg seed to provide ha
- ✓ Seeds treated with fungicide
- ✓ Seeds sown in nursery spaced at 5 cm
- ✓ Germination in 6-7 days
- ✓ Six week seedlings – spacing 60 x 60 cm

Manuring

- ✓ Does not require heavy doses of manures

Interculture

- ✓ Directly sown crop thinned 25-30 days
- ✓ Population 20,000 to 25,000/ha

Harvesting and Drying

- ✓ Harvesting from January to March (150-170 days)
- ✓ Maturity drying of leaves – berries red
- ✓ Entire plant uprooted – roots separated by cutting 1-2 cm above crown

- ✓ Transversely cut into smaller pieces 7-10cm for drying
- ✓ Occasionally roots dried as whole
- ✓ Berries plucked from dried plants threshed to obtain seeds

Grading

- ✓ Dried whole roots undergo cleaning, trimming and grading

1. A-grade – roots pieces 7 cm length, solid 1-1.5cm dia -brittle -pure white inside

2. B-grade – Root pieces 5 cm length, solid, diameter less than 1cm, brittle, white inside

3. C- grade- Root pieces 3-4 cm length –diameter less 1 cm or less

4. Lower yield – Small root pieces – semi solid – very thin and yellow inside

Yield

Average yield 300-500 kg/ha dry roots 50-75 kg/ha- seeds

Belladonna

S.name: Atropa belladona, *A. acuminata*

Family : Solanaceae

Origin: Southern and Central Europe

Economic part: Leaves, roots flowering stalks

Active Principle: 1-hyoscyamine (major) Atropin (minor)

Belladonna commonly called deadly night shade plant.

Acuminata – Indian atropha or Indian belladonna

- In world - drug is from belladonna
- In India- mixture of belladonna and acuminata
- Leaves and roots contain alkaloid 0.13 to 0.7% (Average 0.45%)
- Acuminata leaves contain 0.45% hyoscyamine
- Roots 0.20 – 0.8% (0.4% average)
- Cultivation in UK, Germany, Poland, Hungary, USSR, USA, Rumania, Czechoslavakia, Algeria.

Uses:

- In India – Jammu and Kashmir
- Belladonna leaves – tinctures, extracts and plasters.
- Anti asthamatic and anti inflammatory
- Controls stomach disorders
- Cure over sweating, poisons like opium and floral hydrate
- Roots –Rheumatism and epilepsy.

Climate

- Temperate plant
- Perennial in temperate – more herbage and alkaloid yield
- In subtropical – winter crop – behaves annual – dies in summer – yield is poor
- Grown in open and partial shade

Soil

- Grows well in slightly acidic – deep fertile
- Rich in humus
- Avoid heavy and water logged soils

Land Preparation

- Repeated ploughings – fine tilth
- FYM 25 T/ha last ploughing

Propagation

- Seeds extracted from berries – September to November
- 4 kg/ha
- Germination is poor – 3-6 weeks for germination
- Seeds treated – 80% sulphuric acid at end – 2 minutes
- Stratification – 5 to 12^0C or - 2 to 2^0C for 10-40 days

Nursery

- Direct sowing treat nursery – best results

- Raised beds of 3 x 1m – well decomposed FYM top 10 cm soil

- Seed treatment

- Seed mixed with fine sand 1:40 – 200 g

seed /m^2

- seeds germinate in 3 week

- Seedlings will ready – height 15-20cm –

  8-12 weeks

Broad casting

- 20 kg/seeds/ha

Transplanting

- Planted at 50-60cm in rows 60-70 cm apart
- Better to plant on raised beds with 1 m wide strips
- Irrigation immediately after planting

Irrigation

- More water
- 6-7 irrigations – interval 10-15 days
- Avoid water stagnation

Manuring

- Exhaust crop
- NPK – 25-40 – 40-60 – 30-50 kg/ha – basal
- Additional – 60-80 kg N – 3-4 splits – monthly interval

Harvesting

- First harvest of leaves – 3 months after planting
- Initial yield poor – few leaves – later increases
- Harvesting – starting of flowering – alkaloid is high
- Leaves are cut- cutter (pruning scissor) – 30 cm ground level- 7.5 cm from ground level.
- First year – 3 to 4 crops
- Retained for 3-4 years

Drying

- Leaves dried immediately – shade or sun or wire racks- care remain green
- May also dried with artificial heat
- Spread in thin layer – tuned frequently
- Woody stems discarded
- Prolonged drying reduce alkaloid content
- Roots after 3 years
- Washed – cut to 4 inch long splits – shade or sun dried
- Dried crop stored in cool and dry place

Yield

- Ist year dry leaves – 6 q/ha
- IInd year dry leaves 12 q/ha
- IIIrd year dry leaves 15q/ha
- IVth year – roots yield – 1.7 – 3.35 q/ha
- Alkaloid content in leaves – 0.35%
  Roots – 0.5%

COLEUS

S. name *coleus bar batus*

Family – Limiaceae

- ✓ Tuberous roots are – rich source for forskolin (syn-coleonol)
- ✓ Drug for hypertension, glavcoma, asthma, congestive heart failures and cancers.
- ✓ Pashana bedi in Sanskrit – patharchur in hindi
- ✓ Tuber roots – resembles carrot in shape – brown in colour – commercial product

Botany

- ✓ Aromatic perennial herb – thick tubers showy bluish to pale lavender colour flowers
- ✓ Entire plant is aromatic (fresh or dried)

Varieties

- ✓ Karnataka – K-8- give 0.5% forskolin

Soil

- ✓ Best porus – well drained soils
- ✓ pH 5.5-7
- ✓ Marginal fertility – red sandy loams

Climate

- ➢ Crop of tropics
- ➢ Humid climate RH 83-95% and temperature 10-25^{0}C
- ➢ Annual rainfall 100-160 cm – June- September

- Perform well in less humid and warm regions irrigated crop.
- Propagated by seeds – stem cuttings
- Seed- difficult – breeding of new varieties
- Cuttings – easy- economical –raise crop on large scale

Nursery

- Viability poor (8-10%)
- 15-20 days for germination
- 45 days old seedlings – 8- 10 cm height

Vegetative propagation

- Through terminal cuttings – 10-12 cm long cuttings 3-4 pairs of leaves – prepare nursery beds
- No problem in rooting
- After month – sufficient rooting – main field

Planting

- June – July
- Ridges and furrows at 60 x 20 cm

Manuring and Fertilizers

- 40 kg N, 60 kg P_2O_5 and 50 kg K_2O /ha

Irrigation

- Immediately after transplanting
- Irrigation – one in three days – thereafter
  Weekly

Harvesting and Yield

- Flowers – nipped off – more bio mass
- Ready for harvest – 41/2 – 5 months after planting
- Plants loosened uprooted – tubers separated – cleaned sundried for extraction forskolin
- 1500-2000 kg/ha dry tubers
- 2500 kg/ha – proper cultivation

Diascorea

S.name: Diascorea floribunda
Others: D. *Composita*
D. *dettoidea*
Family: Diascoreaceae Origin: Mexico
Economic Part: Tuber
Active Principle: Diosgenin

- Also known as medicinal yam
- Dioecious plant – climbing habit – perennial- tuberous roots
- Steroid drugs 6% of pharma industry
- Costly and important – Anti fertility property
- Diosgenin – base chemical – steroid hormones like sex hormones – cartico steroids – oral contraceptives
- Rich in proteins, CHO and other alkaloids yamogenin, sofogenin and keptogenin
- Mexico is the largest producer

Species and cultivars

1. D. *deltoidea*

- Indigenous grown wild – north western

Himalayas

Slow growth -7-10 years

Not attractive to farmers

2. D.*floribunda*

- Native of mexico (central America) grown in Karnataka, Goa, Assam, Meghalaya and Andaman and Nicobar islands

- Easily propagated and dioecious

- Three varieties

- IIHR – FB (c) -1 and Arka upkar

- Pusa- 1 by IARI

3. D. *Composita*

- Native of mexico

-Robust climber – produce large thick leaves

- Propagated by seeds – rotting of tubers

Soils

- Light or sandy soils – heavy irrigation and fertigation
- Heavy clay soils – restrict tuber growth – water logging
- Best yields – medium loam and deep soils – rich in O.M
- Highly acidic and alkaline – avoided

Climate

1) D. floribunda, D. Compesitae — Grown in tropical conditions
2) D. deltoid — Temperate – Kashmir & Himachal Pradesh

Propagation

- Propagated by – seeds, rhizomes pieces of stem cuttings
- In India – tuber cuttings
- Seed progeny – variable – longer time to yield
- Choice – cost and prevailing climate of region

Tuber propagation

- Tubers divided – 50-60 g pieces
- Crowns (stem end) 2 Medious (middle) 3. Tips (distal end)
- Crowns germinate in 30 days – other 100 days
- Crowns contain less diosgenin-planting
- Sprouted planted in filed

Season of planting

- Tubers planted in February- March or June – July
- Median and tips early planting – more time for germination

Propagation by seed

- Successful in D. floribunds and D. composite
- Seed – wide membranous with – removed – without affecting germination
- Sown on raised bed
- Seeds germinate within three weeks – ready for transplanting 3-4 months

- Best season for planting start of rains i.e. June

Stem cuttings

- D. floribunds propagated by stem cuttings – 80% success
- One or two old month vires - single mode cutting – one leaf

Land Preparation

- Plough we1l, harrowed, conve nient size plots
- Drianage channels

Planting

- Sprout tubers planted at 5cm depth 30-45 cm apart
- Spacing of 60 x 30-45 cm
- After sprouting earthing

Stacking

- Vine need support – expose leaves to sunlight – photosynthetic activity more
- Reduces pest and disease problem – aeration
- Main support is given in the forms of trellies
- Trellies – stone pillars or iron poles – spaced at 10 m apart
- GI wires – four ends – interconnected with wires

Manures

- 30-150-150 kh/NPK/ha
- Entire P as basal
- N & K in 4 splits
- Each split – monthly – 2 MAP
- Increase tuber yield – S, Calcium and Magnesium

Irrigation

- Irrigation frequently
- Summer 4-5 days
- Winter 7-10 days

Inter cropping

- Intercropped with cowpea, cluster beans, kidney beans

Harvesting

- D.*floribunda* and D.*Compositae* – harvested after two years
- D. *deltoidae* – After 3 years
- Harvested in February-March
- Manually pickaxes – lifted
- Harvested in dormant stage – more diosgenin content

Yield

D.*deltoidae* – 15-20 T/ha – fresh tuber yield

Diosgenin content – 2.5 – 3% - Ist Year

3. 0 – 3.5% - IInd Year

GUGGAL

S. name *Commiphora mukul*

Family – Bureraceae

- ✓ Guggal or Indian bedellium – small tree
- ✓ Source for Indian bedellium – oleo gum resin – incision of bark
- ✓ Resin occur in vascular or stalactite pieces, pale yellow brown or dull green – bitter-aromatic taste balsamic odour.
- ✓ Oleogum resins mixtures of resin (61%) gum (29.3%), volatile oil (1.45%).
- ✓ Largely used in fixative in perfumes and medicines
- ✓ In medicine astringent, antiseptic, stomachic, carminative and digestant
- ✓ The oleo resin – increases leucocytes in blood

Botany

- ➢ Tree or shrub 3-4 high
- ➢ Branches crooked, knotty, aromatic-end in sharp spines
- ➢ Bark is papery and peels in strips – old part of stem

Varieties

- ➢ Marusudha- high yielder

Soil

- ➢ Not grown on commercial scale
- ➢ Naturally in western India – sandy – silt loam – poor in organic matter.
- ➢ Average soil suitable for cultivation

Climate

- Wide adaptability – arid regions – varying conditions
- Prefers a warm, dry climate – yield aloe resin gum

Planting

- Pits at a spacing 3 to 4 m in rows.

Cultivation

- Seeds – vegetatively – stem cuttings
- Air layering is successful

Seed

- Not a common method
- Poor germination – slow growth – hard seed coat
- Mechanically scarified – sand paper-running water (24 hours)
- Raised in poly bags

Stem cuttings

- 15-20 cm long and 10 mm thick semi hard wood cuttings
- Treated with GR(IBA or NAA) – planted in beds
- Cuttings sprout in 10-15 days – grow well – 10 -12 months
- Percentage of rooting 80-94%

Manuring

- Urea or Ammonium sulphate 20-50 g/bush- before irrigation.

Irrigation

- Light irrigation – summer – good growth of Plant

Gum tapping and Yield

- Normal height after 8-10 years – ready for tapping
- Tapping gum – balsam canals phloem
- Shallow incision on bark. Too deep – plant may die low yield next year
- Making incision – small quantity guggal gum mixed applied to incision place – using prick chisel
- Sharp and chisel dipped in guggal solution incision is made
- Incision is made after November – Before April
- Resin collected 10-15 days interval

- 700-900 g/plant

Separation of resin from gum

- Hot expression or solvent extraction at 120- 130^0C
- Purified resin – transparent – translucent – even opaque in built

ISABGOL (Plantago)

S. name : *Plantago ovata*

Family : *Plantaginaceae*

- ✓ Commonly known as Isabgol or blande psyllion Indian Plantago or Psillium
- ✓ Commerce seed and husks
- ✓ Boat shaped seeds
- ✓ Plantago – sole of foot-shape of leaf
- ✓ Psyllium-Greek-Flea-colour size and shape of seed (fleaseed)
- ✓ Husk is economic part – separated by physical process
- ✓ Husk – absorbing and retaining water-anti diarroheal drug
- ✓ Seed-cooling and demulscent effects
- ✓ Constipation and intestinal disorders works as calorie fibre food

Botany

- ✓ Stemless or short stemmed – highly cross pollinated –annual herb
- ✓ Attains 30-40 cm height

Varieties

- ✓ Gujarat Isabgol -1
- ✓ Gujarat Isabgl-2
- ✓ Niharika – CIMAP, Lucknow

Soil

- ✓ Irrigated crop – genus well in light soils
- ✓ Heavy soils – not conducive to good growth
- ✓ Silky loam – pH 4.7 to 7.7.

Climate

- ✓ Warm temperate regions
- ✓ Cool dry weather – winter months
- ✓ Sowing – I week of November best yields

Cultivation

- ✓ Five with for good germination
- ✓ 10-15 t FYM/ha
- ✓ Field – suitable plots
- ✓ Light soils – 8 x 3 m plots are prepared

Seeds and Sowing

- ✓ High percentage of germination – end of preceding season
- ✓ Older seed- loose viability
- ✓ Seedrate 4-8 kg/ha
- ✓ Seeds small and light – mixed with sand
- ✓ Seeds are broadcasted – swept with broom – to cover soil
- ✓ Followed by irrigation
- ✓ Germination – in four days

Fertilizer Application

- ✓ Does not require heavy doses
- ✓ 50 kg N: 25 kg P_2O_5 and 30 K_2O /ha

Irrigation

- ✓ Immediate after sowing – light – if fast seeds one side
- ✓ 6-7 irrigations

Harvesting and Processing

- ✓ Blooming- two months ready for harvest in February-March (110-130 days)
- ✓ Mature – turn yellow – spikes brown in colour
- ✓ Seeds shed – spikes pressed even slightly
- ✓ Harvest-atmosphere must dry – no moisture on plant considerable seed shattering]
- ✓ Harvested after 10 AM
- ✓ Plants are cut or uprooted
- ✓ Bundled in large cloth pieces – threshing yard
- ✓ Threshed – with tractor – morning – easy separation of seed from spathe
- ✓ Water sprinkled – heap-easy threshing

- ✓ Threshed – winnowed – seeds sieved
- ✓ Seeds may be marketed whole – husk may be sold separately
- ✓ To remove husk – cleaned seeds passed 6 to 7 times through stone grinders
- ✓ Highest quality husk-white-no particles of kernals
- ✓ Husk seed ratio in 25:75 by weight

Nuxvomica

Strychmus nuxvomica

Poision nut Snake wood

Mushini

Vishamushti

F: Loganiaceac

Active Principle:

It is perennial plant lines for 15-20 years

- Nuxvomica leaves, seeds, root and bark are useful parts.
- Leaves are used to control itching act as stimulant nervous disorder
- Root and bark used to control fever
- Seeds used to control dysentery, ulcers, and excitement.
- It is grown in natural forests of Eastern and Western Ghats in India.

Climate

- It is grown in Tropical and Subtropical climate
- Grown in full sunlight
- 100-200cm annual rainfall
- Temperature of 25-40^{0}C is ideal.

Soils

- Comes up well in clayey loam soils
- Ideal soil pH is 6.5 – 7.0
- Light soils must be avoided

Propagation : By seed

Field Preparation: Prepared well by deep ploughing level the land. Pits of 50 cm^3 should be dug out of 5x 5and left for weathering 6-8 months etc seedlings collected and planted in the centre of pit and watered immediately.

Irrigation:

- New plantation should be watered regularly till the establishment.
- Later the plants are irrigated at 7-10d during summer
- 15-20d during winter season.

Maturity & Fertigation:

- FYM @ 10 t/ha applied during the filling of pits after weathering
- Apply 50:30:30 kg of NPK/ha

P &K applied at the filth

Applied ½ dose at the filth

½ dose at the filth

The dosage must be given every year as the plant is growing.

Interculture: Keep the plantation weed free by regular weeding.

Harvesting : The plant comes to flowering and fruiting after 5 years

- The matured fruits change the co. from green to yellowish orange
- The seed can be extracted from the fruits by cutting and cleaning
- Seed yield – 4-5q/ha

OCIMUM

S. name *Ocium sanctum*

Family *Labiatae*

- ✓ Sacred basil or holy basil – biennial – triennial
- ✓ Leaves-steam distillation –yield bright yellow possess odour
- ✓ Plant contains phenols, Aldehydes, tannins, saponin and fats
- ✓ Essential oil components – Eugenol (71%) eugenol methyl ether (20%)
- ✓ Terpeneurobsolic acid anticancer properties – isolated

- ✓ Seeds – greenish yellow fixed oil contain – antistaply loceagulase – extracted with water and alcohol
- ✓ Plant pot herb – leaves condiment is salads.
- ✓ Leaves, seeds, roots- medicinally important.

Botany

- ✓ Erect, herbaceous, much branched softly hairy plant

Types and varieties

- ✓ Two types of O.Sanctum
- ✓ Green type (Sri tulsi) second (Krishna tulsi) – purple leaves

Soil

- ✓ Wide variety of soils – rich loam to poor laterite soils – saline, alkaline, slightly acidic.
- ✓ Well drained soil – good growth
- ✓ Water logging – root rot

Climate

- ✓ Grow partial shade also – less oil
- ✓ Flourishes well – high rainfall – humid conditions.
- ✓ Long days and high temperatures – favour Growth

Season

- ✓ Raised in third week of February –
  Transplanting in middle of April

Propagation

- ✓ Propagated by seeds
- ✓ Highly cross pollinated
- ✓ Fresh seed – pedigree block

Nursery

- ✓ Raised beds
- ✓ 200-300 g seeds/ha
- ✓ 2 cm deep in nursery beds

- ✓ Seeds germinate 8-12 days
- ✓ Seedlings ready 6 weeks 4-5 leaf stage

Transplanting

- ✓ Spacing 40 x 40 cm 40x 50 cm and 50 x 30 cm

Fertilization

- ✓ 120 kg N/ha 60 kg P_2O_5/ha

Irrigation

- ✓ Depend on soil moisture
- ✓ In summer 3 irrigations/ month
- ✓ 12-15 irrigations

Harvesting and Yield

- ✓ Harvesting – full bloom
- ✓ First harvest 90-95 after planting – after 65-75 days intervals
- ✓ Bright sunny days – good quality oil
- ✓ Cut 15-20 cm ground level
- ✓ Wilt in field for 4-5 hours – reduce moisture content and bulkiness
- ✓ About 5 t /ha twice or thrice year
- ✓ Whole herb contain 0.1-0.23% essential oil
- ✓ Oil yield 10-23 kg/ha

Opium

S. name: *Papaver somniferum*

Family: Papaveraceae

Origin: Western Mediterranean Region

- ✓ Outstanding medicinal plant – products opium and codeine used for analgesic and hypnotic effects.
- ✓ Semi synthetic drug from morphine known as heroin worldwide social problem
- ✓ Cultivation in Madhya Pradesh, Rajasthan and U.P
- ✓ Erect – rarely branched annual – height 60-120 cm
- ✓ Flowers large – bluish with purplish base or white purple or variegated.
- ✓ Capsular type of fruits – latex known as opium – lancing

- ✓ Fruits 2.5 cm diameter – globase in shape
- ✓ Seeds reni form – white or black in colour
- ✓ All parts – milky white latex unripe capsules – large amount

Climate and Soil

- ✓ Temperate climate – grown in winter sub tropical regions
- ✓ Cool higher yield – higher day/night – affects yield
- ✓ Frosty, desiccating, cloudy, rainy – reduce quantity and quality
- ✓ Prefers well drained, highly fertile. Light black loamy – optimum pH 7.0

Varieties

- ✓ Number of races by local names
- ✓ Talia, Dhola chola Gotia Ranghatak, MOP3, MOP16, Shama, Shwetha, BROP 1, Kirtiman, Chetak, Trishna, Jawahar, Aphium 16, Sujatha, Shubra

Sowing

- ✓ Land prepand – convenient size beds
- ✓ Seeds – broad casted – is lines
- ✓ Before sowing – treated with fungicide
- ✓ Mixed with sand – uniform spread
- ✓ Line sowing preferred
- ✓ Best time – October – November
- ✓ Seed rate 7.8 kg/ha for broadcasting – 4-5kg/ha line sowing
- ✓ Spacing 30 x 30 cm
- ✓ Germination 5 to 10 days
- ✓ Thinning – uniform growth and development
- ✓ Done at 5-6 cm height – 3-4 leaves
- ✓ Carried upto 14-15cm height – 3-4 weeks after sowing.

Manuring

- ✓ Improves yield and quality
- ✓ FYM 20-30 t/ha
- ✓ 60-80 kg/N and 40-50 kg P_2O_5 – no potash

Irrigation

- ✓ Careful irrigation schedule
- ✓ Light irrigation – after sowing – light irrigation after 7 days

- ✓ 12-15 days till pre flowering – reduced 8-10 days during flowering and capsule formation
- ✓ Moisture stress at fruiting and latex extraction – reduce yield

Lancing and Latex collection

- ✓ Starts flowering in 95-115 days
- ✓ Petals shedding – 3-4 days after flowering
- ✓ Capsules development – 15-20 days of flowering – lancing at this stage – maximum latex
- ✓ Stage judged by – compactness – change in colour from greenish to light green coloured ring in capsule – stage is called industrial maturity
- ✓ Skilled labour – on bright sunny day between noon and 4.00 pm
- ✓ Hottest day – pellicle is form on fresh latex due to hot sun- greater evaporation and quicker thickening. Prevents latex falling off the capsule
- ✓ Started at end of field – works backward to avoid contact with exuding latex
- ✓ Lancing instrument called nastar or naka comprises four lines – ordinary needles spaced at 1.5-2mm apart
- ✓ Nastar held carefully one holds a pencil incision is made swift by swift- down ward stroke starting just below stigmatic rays
- ✓ Depth is controlled – too deep latex exuded to interior
- ✓ If shallow- latex low
- ✓ Incision 0.4 cm ideal
- ✓ Immediately lancing latex exudes- initially milky and accumulated is outer wall of capsule
- ✓ Quickly darkens and dries – collected next day before 10 am- scraping with trowel called seeloah
- ✓ The semi dry blackish latex transformed to wooden trays
- ✓ Grades

  A= Morphine more than 12%

  D_1= Morphine 11-12%

  B_2= Morphine 10-11%

  B= Morphine 8-10%

Harvesting and Flowering

- ✓ Crop left for drying – 20 – 25 days – last lancing on capsule – stops exudation of latex
- ✓ Capsules harvested – plant is removed with sickles
- ✓ Harvested capsules dried is open yard – seeds collected by heating with wooden rod
- ✓ Yield of raw opium 50 to 60 kg/ha

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Periwinkle

S. name *Catharanthus roseus*

Syn *Vinca rosea*

Family – Apocyanaceae

- ✓ Perennial ornamental herb
- ✓ Medicinal properties due to indole alkaloid Ranbasin (ajmalicine)
- ✓ Serpentine – roots – antifibrillic and hypertensive properties
- ✓ Leaves contain – vinblastine and vincristine – constituents of patented cancer drugs

- ✓ Vincristine –maximum in roots (0.75-1.20%) followed by leaf (0.60 – 0.65%)
- ✓ USA imports leaves – West Germany, Italy, Netherlands and UK imports roots
- ✓ Pink and white flowers
- ✓ Flexible long branches – flowers 2-3 cymes – fruits cylindrical follicle with may black seeds

Varieties

- ✓ No recognized varieties
- ✓ Three local types based on colour of flower
  alba – white, roseus –pink and rose coloured
  ocillata – white flowers with rose purple spot in centre.

Climate and soil

- ✓ No specific
- ✓ Tropical and sub tropical areas – natural environments
- ✓ Well distributed rainfall 100 cm or more
- ✓ Grows is any soil except alkaline or water logged
- ✓ Light sandy soils rich in humus preferred for large scale cultivation

Propagation

- ✓ Propagated from seeds
- ✓ Fresh seed – loose viability in long storage
- ✓ Direct sowing or nursery and transplanting
- ✓ Direct sowing – large area – reduce cost
- ✓ 2 to 3 kg/ha – mixed with sand 1:10
- ✓ Beginning of monsoon – 45 cm row apert
- ✓ Grow thinned 25-30cm apart
- ✓ Nursery – 500 g seed – 200m^2 bed – one has
- ✓ Seeds sown in bed – March April – 1.5 cm deep
- ✓ 10 days seed germinate - 2 months ready for transplanting
- ✓ Planted at 45 x 30 or 45 x 45 cm.

Cane

- ✓ Two weedings at 30 and 60 days
- ✓ Do not require much water
- ✓ Monsoon restricted – 4-5 irrigations – good yield
- ✓ No manuring for but good yield
- ✓ 15 T FYM 50:75:75 NPK/ha

Harvesting

- ✓ Roots ready for harvest – after one year
- ✓ Two leaf strippings – one after 6 months – second after 9 months – third stripping – after one year
- ✓ For seed – mature fruits – hand picked – dried in shade – threshed lightly – shade drying – thresh lightly – germination poor
- ✓ Usual – uprooting – shade drying – thresh lightly – germination poor
- ✓ Roots – crop cut 7.5 cm above ground – dried for stems leaves and seeds
- ✓ Field is irrigated – ploughed- roots collected
- ✓ Roots washed – dried in shade – bundles – Marketing

Yield

- ✓ Rainfed – 0.75 T roots – 1.0 t/ stems – 2 T leaves (dry wt)
- ✓ Irrigated – 1.5 T each roots and stems 3 T leaves / ha.

Sarpagandha/Rauvolfia Serpentina

Apocynaceae

Origin: South East Asia

Active Principle – Reserpine

Part- Root

- It is the important native medicinal plant in India.
- It has a history of 400 years using the roots in treatment of snake bite, insect, stings, nervous disorders, epilepsy, skin disorders, excess sweating and itching.
- Used in treatment the hypertension
- It's importance in modern medicine (Allopathy) was recognized in 1952 of the isolation of alkaloid reserpine from the roots used for control of hypertension and sedation.
- In India it is grown in Punjab, Sikkim, Assam, Eastern ghats, Western ghats, some parts of Central and Southern India and Andaman, Goa, Coorg in Karnataka, Kerela, Orissa, Andhra Pradesh and Madhya Pradesh.

Soils:

- Grows in wide variety of soils from sandy alluvial loam to red lateritic loam
- It prefers clay or clayey loam with high % of human
- It pH is >8 growth is not good.
- So the ideal pH is 4.6-6.2

Climate:

- It grows well in hot humid conditions grown in sun and partial shade
- Prefers tropical and sub tropical belt
- Temperature of 10-30^{0}C is well suitable
- High rainfall of 250cm/year is good also comes up well even if reference is --- upto 500 cm
- Plant sheds the leaves during the cold months in localities with severe winter
- Frost kills the top tender green twigs

Propagation by seed, stem cuttings, root cuttings, not stump

Field Preparation: Deep ploughed during may (summer, ploughing)

- When rains come apply FYM 25-30t/ha and mix well with the ploughed soil
- Level the land make into beds with the irrigation channels.

Planting:

- Seedlings of 7-15 cm height with 4-6 leaves planted with a spacing of 45-60x30cm spacing

- Immediately after planting, the field is irrigated

Irrigation:

- Newly planted field should be irrigated frequently
- Please irrigation at an interval of 7-15 d during summer

5-20 d during winter

Manuring & Fertigation

- 'N' application inclusive the vegetable growth but ---- the not growth
- Com—of N with P give better not growth
- FYM 25 – 30t/ha applied during last ploughing
- 20:30:30 kg of NPK/ha applied
- Top dressing of N @ 20kg/ha done twice

Inter cultivation

- 2-3 weeding done in the 1st year one flowering done during February-March for good development of—
- The heavy rainfall areas, the plant must be earthed up to facilitate drainage

Harvesting

- The roots will be ready for harvesting from 15-36 m depending on cultivation
- In Indore the crop is ready for harvest in 18 months
- In Dehradun the crop is ready for harvest in 18 months
- Maximum root yield obtained when the age is q8 months
- The plant is defoliated completely during winter roots drying up and light irrigation is given, roots lifted by digging the soil.
- Do not damage the bark of the root as high alkaloid is resent in the bark 40-50% contribution in from bark only
- Roots washed to remove the soil during dried to reduce the moisture to 8
- Maximum alkaloid present in bark
- Total alkaloid present in bark

Yield

- The plant raised from seeds gives maximum yield of roots than vegetable raised cuttings.
- Seedling yield air dried roots of 1175 kg/ha.
- Stem cuttings air dried roots of 175 kg/ha
- Root cuttings air dried roots 345 kg/ha
- 2nd year- 2200 kg/ha

- 3rd year – 3300 kg/ha

Senna

S. name *Cassia angustifolia*

Family: Leguminosae

Origin: South Africa

- ✓ Leaves and pods – sennosides of A B C D
- ✓ Preparation of laxatives and purgatives
- ✓ India holds leading position
- ✓ Senna leaves exported London market
- ✓ Mainly in southern states – Tamilnadu
- ✓ Erect shrub – 70 cm height
- ✓ Flowers – brilliant yellow – racemose inflorescence
- ✓ Pods – flat – 5-7 dark brown seeds
- ✓ All plants contain but leaves and pods rich for sannoside
- ✓ India 1.5 -3% - Alexandria senna 4.45%

Climate and Soil

- ✓ Legume – no nodules
- ✓ Sandy loam soils pH a 7 to 8.5
- ✓ Sensitive to waterlogging – heavy rainfall low temperature

Land preparation and sowing

- ✓ Land is ploughed – outlet for excess rain water
- ✓ Seed rate 5kg/ha
- ✓ Treatment with fungicide – optimum time –depth important
- ✓ Seeds in line 30-40 cm apart 1.5 – 2.0 cm depth
- ✓ Germination in 13-15 days – one week Hard seed coat remain in hot weather – once germination – sufficient moisture in soil
- ✓ Thinned at 30 days – distance of 30cm

Manuring

- ✓ 4 to 5 cart loads of FYM
- ✓ 80 kgN: 45 kg P_2O_5

- ✓ 40 KgN – 35 – 40 days – 80-85 and 105-110 days (after Picking of leaves)

Harvesting

- ✓ Young senna leaves and pods – high sennoside
- ✓ Sold on basis of weight – balance between weight and content – choose stage of harvest
- ✓ First picking 50 -70 days – second 90-100 days
- ✓ Third picking 130-150 days – entire plants removed – harvested material (leaves and pods together)
- ✓ Roots contain sennoside – not as trade
- ✓ Harvested crop – thin layer in open – to reduce moisture
- ✓ Further drying – well ventilated drying sheds
- ✓ 3 to 5 days dry in sheds
- ✓ Dried produce – 8% moisture
- ✓ Properly dried – light green – greenish yellow colour
- ✓ Improper drying – black or brown luncus sennoside reduce price.
- ✓ Seeds no sennoside – add weight to produce

Solanum/medicinal solanum/steroid bearing solanum

Solanum Khasianum Syn to S. *Viarum*

F: Solanaceae

Origin: India (Assam)

Economic Part: Fruit

Active Principle: Solasodine

The genus Dioscorea tubers are the raw material for production of steroid 'Diosgenin". The plant growth is very slow prolonged maturation period and difficulty in cultivation a search for an alternate crop was made. A new source for 'Diosgenin' was made Solanum Khasianum. It is quick growing, low initial investment for commercial cultivation. It yields a glycoalkaloid "Solasodine" which is nitrogen analogue of Diosgenin.

- Solasodine is converted to testosterone and methyl testosterone and corticosteroids like predinisolone and hydrocortisone.

- These steroids used in anti-inflammatory and antifertility properties. They have large scale usage in health and family planning programme.
- Used for acute rheumatoid arthrite, asthma, leukemia and skin disorder.
- In India – Maharashtra, Central India, Sikkim, West Bengal, Orissa, Nilgirihills.

Soils:

- It is a hardy plant cultivation on a wide range of soils and under different agroclimati conditions
- Water logging is avoided
- Succesful cultivation is in red lateritic soils with organic matter
- Clayey soils are not suitable.

Climate

- It is a long day plant
- It requires sunny weather conditions
- It grows up too elevated of 2000m above MSL
- Growth and development is best under mild conditions.
- Maximum temperature of 35^0C and minimum temperature of 20 ideal

Propagation:

By seed 1.25kg seed rate/ha

Land preparation

- The field is prepared thoroughly
- Apply 25 T FYM/ha during last ploughing
- Divide the field into convenient size plots.

Planting

- The seedlings of 10-12 cm, height, 4-5 week old are planted into plots
- Spacing varies 50 x 50, 75 x 75 and 90 x 120 cm depending on the location/region.
- Irrigate the plots immediately after planting.

Maturity and Fertigation

- A dose of 100: 60: 40 kg of NPK/ha applied
- A dose of ½ N+P+K – basal dressing at land preparation.
- A dose of ½ N – when the plants start flowering.
- Green manuring before planting improve the yield by 20%
- A dose of 65:40:40kg of NPK/ha – Bangalore region

Irrigation

- In high rainfall areas – solanum is raised as rainfed crop
- Irrigation given once in a week during the first month
- Later irrigated once in fortnightly

Weeding

- After 3-4 weeks weeding or hoeing done
- When plant growth to 2-3 months age another weeding is done

Flowering and harvesting

- Solanum though it is a perennial herb grown a annual herb and remain in the field for 6 months
- Plant come to flowering 55-60 DAP
- Fruit take 65-70 days for maturity
- Fruit colour change in 80-90 days after pollination.
- Harvesting of berries is a labour intensive operation
- The spines present o the plant hamper the easy harvesting
- Use the gloves for easy and quick harvesting of berries
- Solasodine content is maximum when the green fruits start turning to yellow colour
- All the fruits do not mature at one time
- More no of pickings are done which will spread for 2 months.

Processing of berries

- Lot of care is required
- Fresh berries contain 80% of moisture
- Moisture reduced to 10% to avoid the degradation of alkaloid
- The berries are cut into two halves and spread in thin layers
- Cut berries are turned frequently for uniform drying
- Sundrying give bright yellow color to dried product
- The dried berries give cracking sound and there they are packed in bag for storage.
- 60% of the alkaloid is in seed
- 40% of the alkaloid is in pericarp.

Yield

- Fresh berries – 8000 to 10000 kg/ha – 10t/ha
- Dry berries – 1800 to 2000 kg/ha – 2t /ha
- Solasodine content – 2.5%

STEVIA

S. name : *Stevia rebaudiana*

Family : *Asteraceae*

- ✓ Sweet, perennial herb
- ✓ Leaves are mid green and intensively sweet
- ✓ Compounds in leaves – **sterioside and rebaudioside** fresh – 30 times (fresh) and 200 times more sweet than sugar (refined)
- ✓ Healthy alternative sweetener to sugar
- ✓ Used in tonics for diabetic patients
- ✓ Antifungal and anti bacterial property
- ✓ Cooling effect on eyes
- ✓ Good for wrinkles – skin care

Botany

- ✓ Short day plant
- ✓ Height 45 cm within 3 months
- ✓ Stevioside more – long day

Soil and Climate

- ✓ Red sandy loam soils with 6-7 pH best
- ✓ Heavy soils not suitable
- ✓ Grows best in subtropical climate
- ✓ Sunny climate – semi shade best

Propagation

- ✓ Seed germination poor
- ✓ Vegetatively – stem cuttings and tissue culture

Planting

- ✓ Forming raised beds
- ✓ 15cm height 60cm width
- ✓ Distance between plants 23 cm -30000 plants /acre

Irrigation

- ✓ Ample supply of good water – all year round
- ✓ Frequent irrigation – micro sprinklers

Fertilizers

- ✓ 110 : 45: 45 kg NPK/ha
- ✓ N must for production of dry matter

Harvesting

- ✓ Timing of harvest – No flowering reduces Stevioside content
- ✓ Leaves plucking – entire plant with side branches leaving 10-15 cm from ground
- ✓ First harvesting – 4 to 5 months after planting subsequent every three months
- ✓ 3000 kg leaves/acre
- ✓ After harvesting – drying of leaves
- ✓ Leaf 10-12% Stevioside on dry weight