K.K.Wagh College Of Agriculture,Nashik

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PRODUCTION TECHNOLOGY OF SPICES, AROMATIC, MEDICINAL AND PLANTATION CROPS

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LECTURE-1: Spices – uses – properties and classification – importance of spice industry in India

Spices:

Spices are those plants, the products of which are made use of as food adjuncts o add aroma and flavour (ex. Pepper, Cardamom, Clove, Nutmeg etc), while condiments are those plants, the products of which are used as food adjuncts to add taste only. Both spices and condiments contain essential oils, which provide the flavour and taste. They are of little nutritive value. They are used as whole, ground, paste or liquid form, mainly for flavouring and seasoning food. Most spices increase the shelf-life of food.

Uses of spices:

1. The principal use of spices is to season the insipid foods to impart flavour, aroma and taste.
2. They are also used as preservatives and fumigants.
3. Spices also find use in pharmacy and indigenous medicines.
4. Spices are also used in perfumery, soaps, cosmetics, tooth paste, confectionery, insenses, dyes, etc.

Properties of spices:

1. Spices are well known as appetizers.
2. They add a tang (taste) and flavour to otherwise insipid foods.
3. Some of them also possess anti-oxidant properties.
4. Some of them have preservative qualities (clove and mustard)
5. Some have strong anti-microbial and anitbiotic activities.
6. Several of them possess medicinal properties.

Classification of spices:

There are about 70 spices grown all over the world, which are classified in different ways.

I. Botanical classification (family wise)
Piperaceae - pepper.
Zingiberaceae – Ginger, Cardamom, Turmeric
Apiaceae – Coriander, Fennel, Cumin.
Myrtaceae – Clove, Nutmeg
Fabaceae – Fenugreek
Lauraceae – Cinnamom

II. Plant part useful as spice:
Root spice - Angelica, Horse radish.
Rhizome spice – Turmeric, Ginger.
Bulbous spices – Onion, Garlic. Bark spice – Cinnamom, Cassia
Leafy spices – Mints, Coriander, Methi
Aril spices – Mace.
Seedy spices – Coriander, Celery, Methi
Fruit spice – i) Capsules – Cardamom, Chillies.
ii) Berries – Pepper, Allspice.

III. Depending upon the longevity of spice plants.
Annual spice – Coriander, Mints, Methi
Biennial spices – Onion, Garlic
Perennial spices – Clove, Nutmeg, Pepper etc

IV. Depending upon the type of the plant:
Tree spices – Clove, Nutmeg, Cinnamom, Cassia
Bush spices – Cardamom
Herbaceous spices – Coriander, Fenugreek, fennel, Cumin.
Climber spices – Pepper, Vanilla.

V. Economic importance: Depending upon the magnitude of trade, earnings and use.
Major spice: Pepper, Cardamom, Turmeric, Ginger, Clove, Nutmeg.
Minor spice: Coriander, Fenugreek, Cumin, Fennel.

Importance of spice industry in India:

India is often referred as "Home of spices". This is because many of the 70 spices grown in the world, are native to India. Further, since antiquity, India pioneered in growing spices and exported. India has enjoyed virtual monopoly in the International Spice trade since ancient times.Out of the 70 spices, several of them can be grown in India, whereas in other countries a few spices are only grown. This is because, India has a great extent of diversity in the climate and soils, which enables to grow a variety of spices.Spices were always export – oriented crops not only in India, but also in other spice producing countries. India produces annually about 5.1 million tones of different spices valued at about Rs.
10200 crores, contributing to 25 to 30 per cent of the world production. India is the biggest exporter of spices and annually exporting about 2 million tonnes of different spices and spice products earning a foreign of about Rs. 5240 crores.

LECTURE-2 Ginger – botanical name – family – origin – plant parts used – introduction – botany – varieties – propagation – climate- soil – preparation of land – planting season – seed rate – spacing – mulching – irrigation – manuring
– intercultural operations – harvesting and processing – preservation of seed material

B.N: Zingiber officinale
Family: Zingiberaceae
Origin: South East Asia

Ginger is one of the fine most important major spices of India. India is the largest producer of dry zinger in the world, accounting for more than 60% of world production. 1/3rd of the production of Ginger in the country is exported. Kerala is the largest producer of ginger accounting for more than 40% of the total countries production. In Andhra Pradesh, it is cultivated in Nellore, East and West Godavari, Medak, Visakhapatnam and Srikakulam districts. Dried rhizomes scraped or peeled are greatly esteemed for their aroma, flavour and pungency.

Uses: Ginger is used as a spice.
It is used for the preparation of Ginger oil and oleoresin.
It is used in the preparation of soft drinks, alcoholic beverages. Green Ginger is used in the culinary preparations.
Preserved Ginger is used for the manufacture of processed food. It is used as carminative and stimulant.

Botany:

It is a herbaceous perennial plant but largely grown as annual. Height varies from 30- 90 cm. The under ground stem (Rhizome) grows horizontally, thick, flattened, branched, covered with small scale leaves and fibrous roots.

Varieities: Varieties are named after their places. They are mainly clones.
The following are some of the clones grown in the respective states.
Assam: Jorhat, Nadia, Maran.
Andhra Pradesh: Narsipatnam, Siddipet and Tuni.
Kerala: Wyanad local, Ernad, Kuruppampadi, Thoduphuza.

Exotic varieties:
China: Introduced from China. This variety has got 3.43% fibre. It has too much moisture. The yield of dry Ginger from green ginger is 13- 15%.
Rio-de-janeiro: This variety was introduced from Brazil. It has 5.19 % fibre. It consists more moisture. The yield of dry to green ginger is 16-18%. It became more popular where Ginger is used in green form.
High Altitude Research Station, Pottangi has released the following varieties.
1. Suprabha: It is a clonal selection from Kanduli local. Rhizomes have plumpy fingers and bright grey skin. It yields about 3.4 tonnes per ha. It has got 4.4% fibre.

2. Suruchi: It is a clonal selection from Kanduli local. The Rhizomes are greenish yellow. Its yield is 2.7 tonnes per ha. It has 3.8% fibre.
3. Surari: It was developed as a mutant. Fingers are cylindrical. Yields about 4 t per ha.

Durations of the above varieties vary from 220 to 230 days.

Propagation:

Propagated by seed rhizomes. Rhizomes are cut into small pieces (setts) of 2.5 to 5.0 cm. They may weigh about 15 – 20 grams having one or two buds.

Climate:

It requires warm humid climate. It grows upto 1500 m above MSL. It requires moderate rainfall from sowing to sprouting. It requires fairly heavy and well distributed rains during crop growth period. It requires dry weather from 28 – 35^0C for about a month before harvesting. Prevalence of high humidity and shade are necessary during crop growth period.

Soil:

It requires deep, well drained, humus rich soil. It is sensitive to water logging. It can be grown well on sandy loams, clay loams and laterite soils.

Preparation of land: The land is ploughed repeatedly for 5 to 8 times thoroughly to achieve fine tilth.

Systems of cultivation / planting technique: Ginger is raised by 2 methods viz. bed and ridge system depending upon rainfall and soil type

Heavy rainfall areas	: Beds or ridges.
Low rainfall areas	: Flat beds or ridges.
Irrigated crop	: Ridges & Furrows 40 – 45 cm apart to a height of 30 cm
Rainfed crop	: Raised beds of convenient length and 100 cm wide are prepared with an inter space of 30-40 cm in between the beds for irrigation and drainage

Planting:

i) Season: In Andhra Pradesh, first fortnight of May. Early planting is beneficial.

ii) Seed rate : 1500 – 1800 kg per ha. iii)

Spacing : 45 x 15 cm

iv) Sowing : Treat with Dithane M 45 0.3 percent for 30 min. After treating, seed rhizomes are kept in moist gunny cloth for 2 – 3 days to promote early sprouting.

The crop is mulched after sowing. Sprouting starts within a week and continues for another 3-4 weeks.

v) Mulching:

In ginger cultivation, mulching the field is an important operation. Mulching has several advantages 1. Source of organic manure 2. Prevents washing of soil 3. Conserves soil moisture 4. Smoothers weed growth. 5. Improves the physical properties of soil 6. Protects the setts and sprouts from hot sun 7. Provides favourable conditions for the sprouting of the setts.

First mulching is to be done at planting with 10-12 tonnes of green leave per ha. Second mulching is done at 40-60 days after first mulching with 5 tonnes of green leaves. Farm yard manure is spread over the green leaves. In irrigated crop – raise cow pea and black gram as live mulches. Remove the mulches 60 days after sowing during rains. Castor seeds are sown on bunds at 9 m intervals, to serve as wind breaks.

Irrigation:

Irrigate at 4- 10 day interval. During mid September to 3rd week of December irrigate at fortnightly interval.

Manuring:

At the time or before planting 25 – 30 tonnes of cattle manure 50 kg P_2O_5; 25 kg K_2O are applied as basal dressing. At 60 and 90 days after planting Nitrogen is applied in two splits @ 37.5 and 37.5 kg per ha along with 25 kg K_2O.

In Andhra Pradesh:

Basal dose: 15-20 tonnes of FYM per ha : 60 kg P_2O_5; 30 kg K_2O per ha.

Top dressing: 120 kg Nitrogen (40 + 40 + 40); 60 kg K_2O (20 + 20 + 20) per ha is applied in three equal splits at 40, 80, 120th day after planting.

The plants are earthed up after each application of ferlilisers.

Weed control: Reduce competition by weeds.

3-4 weedings are necessary between June to September. After each weeding, mulch is to be replaced.

Clumps are removed and earthed up in September.

Harvesting: For Green Ginger: 6 months after planting.

For Dry Ginger: 8 months after planting, when leaves turn yellow and start drying between 245 to 260 days.

Preserved Ginger: 7 months after planting. Before they fully mature, after which they become more fibrous.

Light irrigation is given before harvesting. Dig the plants carefully. Soak them overnight. Wash thoroughly. Sundry for a day or two before marketing as green ginger.

Yield: Average yield under rain fed condition is 10-15 tonnes per ha.

Average yield under irrigated condition is 15 – 25 tonnes per ha.

Processing:

I. Dry Ginger: Preparation of commercial dry zinger involves a series of steps. Fully developed rhizomes are harvested after 8 months of planting for preparation of Dry Ginger.

1. Soaking in water: The rhizomes are soaked overnight in cement tubs for easy removal of skin.

2. Trampling: The rhizomes are trampled under feet in the tub. Avoid damage to epidermal cells containing flavouring oil.

3. Peeling: The skin is peeled off, with sharp bamboo knives. Don't rupture epidermal cells. This step hastens drying process.

4. Washing and Drying: The peeled rhizomes are wahsed and sundried for 3-4 days on cement floors.

5. Polishing: After drying the rhizomes are polished by rubbing with a coarse cloth to remove all bits of skin or dirt. These are called unbleached ginger.

To get bleached Ginger, peeled rhizomes are soaked in 2% lime water for 6 hours, fumigated with sulphur for 12 hours.

Yield of dry Ginger is 16 to 25% of the fresh Ginger.

II. Preserved Ginger: Ginger is harvested at 7 months after planted for preparing the Preserved Ginger. It is preserved in syrup or brine.

Rotations and mixed cropping:

Continuous Ginger cultivation – promote exhaustion of fertility and favour the incidence of diseases.

In Irrigated lands – Ginger is rotated with betelvine, banana, turmeric, Onion, Garlic, Chillies, Vegetables, Sugarcane, Maize etc

Ginger can be grown as intercrop in Coconut, Arecanut, coffee, Mandarin, Mango, Guava and Grapes.

Preservation of seed rhizomes:

1. Ginger rhizomes are harvesting during December – January.
2. They are to be planted during April – May. Hence, there is a need to preserve the seed rhizomes for a period of about 4 -5 months.
3. The selected healthy rhizomes are treated with a solution of 0.1 % Quinolphos and 0.3% Dithane M 45 for 30 min.
4. The rhizomes are stored in pits dug in a cool and protected place.
5. Pits of 1 m depth, 1m width and of convenient length are prepared.
6. Walls are plastered with cow dung.
7. Layer of sand is spread at the bottom of the pit.
8. Layer of rhizomes are alternated with dry sand or saw dust layers.
9. Some gap is left at the top for aeration.
10. Pits are covered with wooden planks giving one or two holes for aeration.
11. Entire pit is plastered with mud leaving a hole.

LECTURE-3 : Turmeric – scientific name – family – plant parts used – origin and distribution – importance – botany – varieties – propagation – climate – soil – preparation of land - systems of planting – planting seasons – seed rate – spacing – sowing – mulching – irrigation – manuring – intercultural operations – provision of shade – intercropping – rotations – harvesting – processing – preservation of seed material

B.N: Curcuma longa and Curcuma aromatica
Family: Zingiberaceae
Origin: South East Asia
Plant part: Rhizome

Underground rhizome is used as condiment, dye stuff, drug and cosmetic. Traditional item of export. India is the largest producer of Turmeric.In India, A.P., leads in Area and Production.In A.P., there are five agro-climatic zones.
Duggirala zone , Cuddapah zone, Nizamabad zone, Godavari zone and Agency Turmeric ranks 4th as foreign exchange earner among the spices after Pepper, Cardamom and Ginger.

Botany:

Curcuma has 42 species. C. longa is cultivated in large area in A.P. C. aromatica is grown in some parts locally known as kasturi used for the preparation of kum kum. Erect herbaceous perennial 60-100 cm rhizome with fingers. Rhizome is brown on out side and dull orange coloured inside. Leaves are broadly lanceolate with long leaf stalk.

Varieties: Three categories.

Long duration types : 9 months duration: Duggirala, Tekurpeta, Armor and Mydukur, CLL 324, 325, 326, 327

Medium duration types: 8 months duration: Kothapet, Krishna, Kesari, CLL 317.

Short duration types: 6-7 months duration: Amalapuram, Dindigram, PCT – 13 (Suguna), PCT – 14 (Sudarshan)

Armoor is the popular type in Nizamabad district.

Kasturi and kesari are good in curcumin content, but poorer in curing percentage.

Propagation:

Through rhizomes, mother rhizomes, cut mothers, primary fingers. Planting primary fingers has become a common practice in A.P., because they keep better in storage, more tolerant to wet soil and involve low seed rate.

Preservation of seed rhizomes:

1. Mature, healthy rhizomes are heaped over a layer of sand (5- 10 cm thickness) under shade of a tree or shed.
2. Covered with turmeric leaves.
3. Heaps are plastered with earth mixed with cow dung.
4. Treat with Dithane M 45 0.3% or Bavistin 0.1% solution for 30 min and shade dried before heaping.
5. Remove rotten rhizomes at the end of storage period.

Climate:

Tropical herb.Grows well 1200 m above MSL. Requires warm and moist climate. Rainfall 100 to 200 cm. Temperature range preferable is 20 to 30^0 C

Soils:

Can be grown on various soils. Thrives best in well drained, friable, rich sandy or clay loam soils. Crop stands neither water logging nor alkalinity.

Preparation of land:

Give 4-6 deep ploughings to get fine tilth up to 20 -25 cm depth. Field is laid out into beds or ridges and furrows. Bed system gives higher yield by 54 to 80%. Beds of 1 m width and convenient length with a spacing of 40 to 50 cm between beds where natural drainage does not exist, ridges and furrows are prepared at 45 to 60 cm spacing.

Time of sowing:

Short duration varieties: second fortnight of may
Mid duration varieties: first fortnight of June
Long duration varieties: second fortnight of June to second fortnight of July.

Seed rate: mother rhizomes 2000 – 2500 kg per ha
Primary fingers 1500 to 2000 kg per ha

Spacing:

Red loamy soils – 30 x 15 cm
Black heavy soils – 46 x 23 cm

Method of sowing: sown behind the plough in ridges and furrow system

In bed system, rhizomes are dibbled at 5-10 cm pits.Treat with dithane m 45 0.3% for 30 minutes before sowing. Germination starts in 10-20 days and will be over by 60 days.

Mulching: To protect sprouts.
To conserve moisture
To reduce weed growth
To enhance germination by mulching with dry leaves. Mulch with dry leaves thickly on which a layer of cow dung is spread. Second mulching is done after weeding and application of fertilizers, after 50 -60 days of sowing.

Irrigation:

A good soaking irrigation is given immediately after sowing.Thereafter, irrigate at weekly interval.

Manuring:

20-25 to of FYM during land preparation
60kg N, 60 kg P, 60 kg K per ha before planting the rhizomes.
60 kg N ---------65 kg K per ha 60 das
60 kg N ---------per ha 120 das
50% of top dressed Nitrogen may be applied in the form of oil cakes. Top dressing should be completed within 120 days after sowing.
After fertilization, the field is given a light hoeing and the clumps are earthed up and irrigated.

Weeding:

3 – 4 weedings are required at 60, 90, 120 and 150 days of planting. Weedings and hoeings are done simultaneously. Plants are earthed up and mulch is replaced. Provision of shade. By raising castor on the bunds and within the crop. Daincha is also grown for shade purpose.

Intercrops:

Maize or chillies are grown as inter crops.Turmeric can also be raised as an inter crop in coconut and arecanut plantations.

Rotations:

Turmeric is a heavy feeder. Hence depletes soil nutrients.
Continuous cropping results in build up of diseases.
It is rotated with rainfed paddy, sugarcane, banana, betelvine, vegetables.

Harvesting:

Depending upon the varieties, the crop comes to harvest in 7-9 months.

1. Main season of harvesting falls in February – April.
2. Maturity indication is complete yellowing and drying up of plants
3. Above ground parts are cut close to the ground level.
4. Field is irrigated 1-2 days in advance of harvesting the crop.
5. Crop is harvested by Ploughing or digging.
6. Rhizomes are gathered by hand picking and cleaned.
7. Rhizomes are washed.
8. Mother rhizomes are separated from the fingers before they are cured.

Yield: Indian average yield is 20,000 to 22,000 kg per ha

Processing:

Fresh rhizomes are not useful for marketing. Curing makes fresh rhizomes marketable. Curing involves boiling, drying and polishing.

A. Boiling: is done either by traditional or improved method.

I. Traditional method:

Water is poured to cover rhizomes in the vessels of copper or galvanized iron or earthen material. Mother rhizomes and fingers should be boiled separately, since fingers take long time for boiling. Stop boiling when froth, fumes with typical odour comes.

Rhizomes yield to finger pressure. Over cooking should be avoided as it spoils the colour, while under cooking renders the dried product brittle.

II. Improved method:

50 kg of cleaned rhizomes are taken in a perforated trough made of GI sheet. It is immersed in a pan. Alkaline solution 0.1% sodium carbonate/ sodium bicarbonate is poured in the trough. Boil till fingers become soft. Alkaline solution helps in imparting orange yellow colour to the core.

B. Drying:

The boiled rhizomes are sun dried in 5.7 cm thick layers for 10 – 15 cm layers. Rack frequently for uniform drying. Dry until they become hard, brittle, break with a metallic sound. After drying they should possess only 8 – 10 % moisture.

C. Polishing:

The dried rhizomes are smoothened by manual or mechanical rubbing. Manually they rubbed on hard surface or trampled under feet. Mechanically they are polished by mechanically operated polishing drums.

D. Colouring:

They are coloured to improve the appearance.

Rhizomes are artificially coloured in two ways. Dry and wet colouring. Half polished fingers are coloured.

In dry process – turmeric powder is added in the last 10 min to polishing drum.

In wet process – turmeric powder is suspended in water and mixed by sprinkling. For brighter colour – boiled, dried, half polished fingers are taken in baskets and shaken continuously with an emulsion of

2 kg turmeric powder, 0.04 kg alum, 0.14 kg castor seed oil, 30 g of sodium bisulphate and 30 ml HCl.

Coloured rhizomes are again sun dried before sending to market.

LECTURE-4: Black pepper – scientific name – family – plant parts used – origin and distribution – introduction – botany – varieties – climate – soil – selection of site – systems of cultivation - propagation – planting of standards and vine – shade and shade regulation – training and pruning of pepper vine – manuring – irrigation – intercultural operations – harvesting – yield – processing of pepper

Botanical name: Piper nigrum
Family: Piperaceae
Origin: Western ghats of South India (Malabar)
Useful plant part : Fruits / Berry

Introduction:

Pepper is the most important of all spices and popularly known as the 'king of spices'. Black pepper is a dried mature fruit of perennial ever green climbing woody vine. It is one of the most important earliest known spices produced and exported from India. It is the most valuable and important foreign exchange earner among the important spices earning nearly 50% of the total export earnings from all the spices, because of its importance in the spices and unique position in trade and large share in export earnings, it is popularly referred as king of spices and black gold in trade.

Area and production:

Outside India it is grown in Srilanka, Malaysia, Indonesia, Brazil Mexico, China, Thailand and Madagscar. India accounts for 54% of the total area under pepper in the world but its share of production is only 26.6% whereas the other countries like Brazil, Indonesia, Malaysia accounts for lesser percentage of area but with more share in the total production due to their higher productivity. In India pepper cultivation is confined to southern states only. It is grown mainly in Kerala (96% area), Karnataka, Tamilnadu and pondicherry. Since ancient time pepper is exported from India. On an average of 85% of the Pepper produced in the country is exported to USA, Canada and Italy. Till 19th century India enjoyed monopolistic position in the world market. However now India lost its top position due to low productivity, poor yield and raise of Indonesia and Malaysia countries.

Botany:

Black Pepper is an evergreen. Perennial woody climber reaching to a height of 10 m or more. It has extensive but shallow root system. The vines branch horizontally from the nodes but do not grow longer. Based on the growth habits morphological characters and biological functions, five distinct types of stem portions can be defined in the shoot system of a pepper vine.

1. Mainstem:

It originates from a seed or from a stem cutting. It climbs on a support with the aid of aerial or adventitious roots.

2. Runner shoots:

They are produced from the basal portion of the main stem, growing at right angle to the main stem, usually restricted up to 50 cm from the ground.

3. Fruiting branches (plagiotropics):

They are produced from the nodes of the main stem and they grow laterally more or less at right angles to the main stem, bearing the spikes.

4.Topshoots (orthtropics):

vegetative shoots which arise on the top portion of the main shoots. It gives a bushy appearance with stouter, thicker internodes and with large number of adventitious roots at the nodes. They are used for the propagation.

5. Hanging shoots (geo tropics):

In a fully grown vine, some of the plagio tropics at the top portions are seen to give rise to special type of shoots which hang down and grow geotropically.

Leaves are broadly lanceolate, alternate, simple, dark green and shiny above, pale green and gland dotted under neath. Size and shape vary according to the variety.

The inflorescence is a catkin. Born on opposite side to the leaves on Plagiotropic branches, 5-15 cm long, bearing 50-150 minute flowers. The flowers are monoecious or Dioecious or hermaphrodite (bisexual) forms occurs in different varieties.

High yielding forms should have more percentage of bisexual flowers and in cultivated varieties these plants will be more than 80%. Male flowers are very few 1-19% in different varieties. The fruit is a single seeded berry, sessile, small globose or oval. It has thin pulpy pericarp around the seed. It takes approximately 6 months to mature after flowering. Each spike produce 50-60 fruits. The skin (exocarp) turns from green to red on ripening and black on drying.

Varieties:

More than 75 cultivars of pepper are being cultivated in India. Majority of the cultivated types of Pepper are monoecious.

Karimunda: most popular variety throughout Kerala. A prolific and regular bearer. Dry recovery is 35%. Yields good quality of Pepper. Suitable for intercropping as well as for high density cropping.

Kalluvally: This is grown in North Kerala. It is hardy and regular bearer. It withstands water stress and is moderately tolerant to Phytophthora wilt. Spikes are medium long and have a characteristic twisting due to very thick setting. Driage is 40%. It is grown either alone or mixed with other cultivars. Kottandan, Narayakkodi, Aimpiriyan, Neelamundi, Kuthiravally, Balankottah, Malligesara and Uddagare.

Recently a number of improved cultivars have been evolved and released. They are Panniyur 1, 2 (Krishna), 3 (shima), 4 and 5 : released from Kerala Agricultural University, Pepper Research Station, Panniyur.

Improved varieties of black pepper :

Name of hybrid / variety	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 Kariamunda (KS27)	4.2
Panchami	Selecton from Aimpiriyan Coll . 856	5.2
Pournami	Selection from Ottaplackal Type coll.No.812	4.7

Sreekara, Subhakara, Panchami, Pournami – released from NRCS, Calicut. Malabar types: grown in Malabar region in Kerala. Examples are Kalluvally, Balankottah. They are suitable for shade
Cheriyakody, uthirankottah have high percentage of pistillate flowers.
Malvad types: grown in malvad of Karnataka. Workaiamarata variety is preferred for white pepper other examples include doddagya, karimarata, arasilamarata, malligesara, tisara.
Travancore types: these are hardy, the cuttings root easily and climb the support without external help. Ex.: Karimunda, veluthanamban (tolerant to wilt), kuthiravally, chola.

Uses:

Black pepper is used for a variety of purposes. One of the principal values of Pepper is its ability to enhance the seasoning of dishes. It is valued for its characteristic aroma, hot pungent and biting taste and is mainly used for flavouring and seasoning. It is largely used as preservative by meat packers and in canning, pickling and baking confectionery and preparation of beverages. Oil and black pepper is a valuable adjunct in flavouring of certain beverages and liquors. The oil absorbed in soaps and in perfumes.It is considered a powerful remedy for various disorders such as dyspepsia, malaria, delirium treatments
The aromatic odour of pepper is due to an essential oil, while the pungency is due to oleoresin.The Egyptians used it for embalming. The Asians are said to have used it as an aphrodisiac.It is extensively used in Ayurvedic medicines and pharmacological studies. Alcoholic extract of black pepper was found to be highly toxic to several weevils on stored food products. Pepper extract acts as a effective repellent. The alkaloid ‘piperine’ is considered to be the major constituent responsible for the bitter taste of black pepper, it is absent in the leaves and stems. Piperine has insecticidal effect on its own.

Climate:

Pepper is a tropical plant it requires warm humid climate for commercial production.It grows successfully between 20^0 N and South latitude and from sea level up to 1500 m above MSL. The crop tolerates temperature between 10^0 C to 40^0 C. But it requires an optimum temperature of 25 to 35 degrees Celsius. A well distributed annual rainfall of 125 to 200 cm is considered ideal for pepper. Prolonged droughts stop the vegetative growth of the vines.

Soil:

Pepper can be grown in a wide range of soils such as clay loam, red loam, sandy loam and lateritic soils with a pH of 4.5 to 6.0. It thrives better in soils rich in organic matters.

Propagation:

Pepper is invariably propagated vegetatively (stem cuttings).This is because of variation shown by the seedling progenies and also that the seedlings become diocious and come to bearing very late (7-8 years). Pepper is propagated by cuttings raised mainly for the runner shoots. Cuttings from lateral branches are seldom used, because reduced number of fruting shoots, short living and bushy in habit. He selection of mother vine for perpetuation is done as follows;

1. A variety suitable for locality should be selected for instance Panniyur-1 for open place and Ballankottah for shady location.
2. A variety should be selected depending upon the system of cultivation to be followed for instance, Kalluvally, Panniyur-1 for monocrop system. Balankottah, Karimunda for mixed cropping.
3. A high yielder with high %of bisexual flowers should be selected.

The runner shoots are separated from the vine in February – March and after trimming in leaves, cuttings of 2-3 nodes each are planted either in nursery beds or polythene bag filled with fertile soil. Cuttigs from middle 1/3rd of the shoots are desirable as they are high yielding. Adequate shade is provided and irrigated frequently. The cutting which become ready for planting in May – June.

A rapid multiplication technology has been developed by NRCS, Calicut. In this a trench of 0.75 m deep 0.3 m wide having convenient length is made. The trench is filled with rooting medium (preferably forest soil, sand, cow dung 1:1:1). Split halves bamboos with septa having 8 – 10 cm diameter and 1.25 to 1.5 m length are fixed at 45^0 angle on a strong support. The bamboos can be arranged touching one another. Rooted cuttings are planted in the trench at the rate of one cutting each for one bamboo.

The 10 cm portion of the bamboo are filled with a rooting medium (coir dust and cattle manure at 1 : 1 ratio) and the growing vine is tied to the bamboo in such a way as to keep the nodes pressed into the rooting medium. The tying could be done with dried banana sheath fibre. The vines are irrigated regularly. As the vines grow up, filling up the bamboo with rooting medium and tying each

node, pressing it down to the rooting medium are to be continued regularly. For rapid growth each vine is fed at 15 day interval with 0.25 litres of nutrient solution prepared by dissolving Urea (1kg), 0.75 kg SSP, Mop (0.5 kg) and Megnesium sulphate (0.25 kg) in 250 litres of water. When the vine reaches the top in about
3 to 4 months, the terminal bud is nipped off and the vine is crushed at about 3 nodes above the base, in order to activate the axillary buds. After about 10 days, each vine is cut at the crushed point and removed from the rooting medium and each node is separated. Such cuttings with bunch of roots intact is planted in poly bags filled with pot mixture and kept in cool humid place. Care should be taken to keep the axil above the soil. The buds start developing in about 3 weeks when the poly bags can be removed and kept in semi shade. Subsequent harvesting can be had at every 2 – 2 ½ months time.

Advantages:

Multiplication is rapid

The root system is well developed.

Better field establishment and more vigorous growth as a result of better root system

Selection of site:

Well drained leveled land and hill slopes are suitable for growing pepper. When the grown on a sloppy land, the slopes facing south should be avoided and the lower half of north and north eastern slopes are preferred for planting. So that the vines are not subjected to the scorching effect of the sun during summer.

System of cultivation:

Pepper cuttings are generally planted with onset of South west monsoon. When pepper is grown as pure crop, pits of 0.5 m^3 are dug at a spacing of 2.5 x
2.5 m. Erythrina stem cuttings of 2 m length are its 2 year old seedlings are planted on receipt of early monsoon showers. Certain other trees like silver oak, Ailanthus excelsa and Garuga pinnata are also used. With onset of regular rains, 2 or 3 rooted cuttings are planted around the base of the standard nearly
30 cm away. But in case of coconut and arecanut which have a thick intercoiled root net close to the trunk, pepper cuttings are to be planted 100 to 120 cm away from the tree trunk. Initially the vines may be allowed to climb on a stick or pole about 2 m tall which is tied to the trunk in a slanting position. After one year when the vine has attained sufficient length it may be separated from the temporary stake and the lower leaves may be nipped off. A narrow trench of 15 cm deep and wide should be prepared from the base of the vine to the base of the tree trunk. The vines may be placed in the trench in such a way that the growing tip is tied to the trunk while other parts of vine are covered with soil. A small ridge is formed over the trench, which should not be disturbed while doing intercultural operations to the palm.

Cultural operations:

The pepper vines are tied firmly as and when they grow. The tying is done around the node, so that the nodal region is firmly attached and pressed against

the standards so as to allow the roots to cling to the standards. This is an important operation which has to be attended to carefully as otherwise the vine will have no support. The another practice is that when vine reaches at a height of 75 to 100 cm without branches all the leaves are removed except the terminal
3-4 leaves. The defoliated portions are covered with friable fine soil. This aid in establishing a well developed root system and lateral branches may arise out of them.

Training and Pruning:

The vines are trimmed at the top and prevented from growing too tall for convenience of picking. In Tamil Nadu, pepper vines trained on Silver oak standards are pruned at 6 m height from ground level for easy picking. The vines are trained up the support to give one main shoot and two lateral orthotropic shoots. These are pruned regularly to encourage the development of lateral fruiting branches but these lateral branches should not be tied to support, as this would discourage the bushy side growth.

The vines are first pruned back to 15-20cm from the ground level, when they developed to 8-9 nodes length. Second pruning is done when a further 9-10 nodes have been produced, to a height of 3-4 nodes of the previous cut. In this way vines are pruned 7-9 times until they reach the top of the support about 3 m high. When this is achieved, the terminal growth of vine is arrested by frequent pinching. The lower portion of vine is kept clean and unbranched at least a meter from ground level.

Regulation of shade:

In Pepper plantation, shade is given to the pepper vines, especially during the hot weather to keep the soil cool and moist and to allow sun light during cool weather to encourage production of flowers and fruits.

The young vines should be protected from hot sun during the summer months by providing them with artificial shade. Regulation of shade by lopping the braches of standards is necessary not only for optimum light to the vines but also for enabling the standards to grow straight. Excessive shading during flowering and fruiting encourages pest infestation. Adequate mulch with green leaves, saw dust or coir dust or organic matter should be given towards end of the north east monsoon. The base of the vine should not be disturbed to avoid root damage.

During the second year, practically the same cultural operations are repeated. Lopping of standards should be done carefully from 4^{th} year onwards. From the 4^{th} year, usually 2 diggings are given one during May – June and the other towards the end of South West monsoon in October and November. Growing cover crops like Calapogonium mucanoides, Mimosa invisa are also recommended under west coast conditions to provide an effective cover to prevent soil erosion during rainy season. Further, they dry away during summer leaving thick organic mulch.

Manuring:

Judicious and regular manuring is necessary to get good yields. About 10 kg of well rotten cattle manure or compost is given in April – may. Fertilizers to supply 100 g Nitrogen, 40 grams phosphate and 140 grams of Potash per standard for vines at 3 years and above age may be applied annually in 2 split doses in April-May and August – September. During the first year of planting
1/3rd of above dose and in second year 2/3 rd of the above dose may be given. Manures are applied around the vines at a distance of 30 cm and forked in to the soil. Lime may be applied at the rate of 500 grams per standard. During April in alternate years

Harvesting:

Pepper vines start yielding usually from the 3rd or 4th year. The vines flower in May-June. It takes 6-8 months from flowering to ripening stage. Harvesting is done from November to February in plains and January to March in hills. When one or two berries on spike turn red in early the whole spike is plucked. Yields vary with the variety and season. A full bearing vine yields one kg of dry pepper. However, individual vines recorded yields up to 3-5 kg of dried pepper.

Harvesting of pepper is carried out according to the purpose for which it is harvested.

For preparation of white pepper the berries are harvested at a slightly advanced stage of ripeness i.e when the berries turn red (bright orange). To get black pepper the berries are gathered at younger stages.

Yield:

Pepper vine attain full bearing stage in the 7^{th} or 8^{th} year after planting.
And yield starts decline after 20-25 years and replanting has to be done thereafter. 7^{th} or 8^{th} year old pepper vine gives 800 to 1000 kg of Black Pepper per ha.

Processing of pepper:

Almost all the produce in India is processed in to black pepper and only a very limited quantity is converted in to white pepper.

Black pepper:

It consists of fully developed, but unripe dried berries of Pepper. The harvested spikes are sun dried for 7 to 10 days on cement floor or mats, until the outer skin becomes tough black, shrink and wrinkled. Drying is carried till the moisture content gets reduced to 10-15%. Then the dried berries are separated from the spikes by beating or rubbing between hands or trampling them under the feet. For making good quality of Black pepper of uniform colour, the separated berries are collected in a perforated bamboo basket or vessel and the basket with the berries is dipped in boiling water for 1 minute. The basket is then taken out and drained. The treated berries are sun dried on a clean bamboo net

or cement floor. The recovery of black berry is about 33 % (26 to 36% depending upon the variety).

White pepper:

This consists of dried is prepared by removing the outer skin along with the pulp before drying. White pepper is prepared by one of the two methods

I. Water steeping technique (traditional method)

II. Steaming or boiling technique (improved method)

I. Water steeping technique:

It is a traditional and slow method. It involves 5 steps.

1. Steeping: Spikes with fully ripe berries are filled in gunny bags and are steeped in flowing water for about 7 -8 days. During this steeping process, the skin gets loosened from the seed.
2. Depulping: At the end of steeping, the berries are taken out and the skin with the pulp is removed either by rubbing between hands or by trampling under feet.
3. Washing: These depulped seeds are then washed and cleaned with fresh water repeatedly (3-4 times)
4. Drying: The cleaned seeds are sun dried for 3-5 days on cement floor or mats till they become white and the moisture gets reduced to 10-15%.
5. Polishing: The dried seeds are now dull white with colour. They are further cleaned by winnowing or by rubbing with a cloth.

The percentage of recovery of white pepper is about 25% of ripe berries.

II. Steaming or boiling technique:

This is an improved and quick method developed at CFTRI, Mysore. It involves 4 steps.

1. Boiling: Freshly harvested spikes or berries are boiled for about 15 minutes.
2. Depulping: The boiled berries are then pulped mechanically. Boiled berries passes through motorized fruit pulping machine.
3. Bleaching: The depulped berries are washed thoroughly by using bleaching powder or any bleaching agent.
4. Drying: The cleaned berreis are sun dried for 3-5 days on cement floor or mats till they become white and the moisture gets reduced to 10-15%.

LECTURE-5 : Cardamom – botanical name –family – plant parts used – origin and distribution – introduction – botany – varieties – climate – soil – preparation of land – propagation - planting of standards and cardamom – shade and shade regulation – manuring – irrigation – intercultural operations – cropping – harvesting – processing and yield

Small or lesserCardamom: Elettaria cardamomum (Malabar cardamom) Large Cardamom: Amomum subulatum (native to Eastern Himalayas) Bengal cardamom: Amomum aromaticum
Family: Zingiberaceae
Origin: Western ghats of South India (kerala)
Useful plant part: Fruit (capsule)
Cultivated cardamom has chromosome number 2n = 48.

Out of the above species, most popular species occupying a premier position is small cardamom.Large cardamom is mainly cultivate in Dargeeling, Assam, Himalayas, Nepal, Bhutan,Thailand, Indonesia.Bengal cardamom is grown in Northern Bengal.

Introduction:

Cardamom is popularly known as the Queen of Spices and also Green Gold. It is one of the ancient species of India and is also one of the most valued spices of the world. It is next only to black pepper as the largest foreign exchange earner among various Indian spices.

Cultivation of Cardamom is mostly concentrated in the evergreen forests of western ghats in South India. Besides India, Cardamom is cultivated in Guatemala, Tanzania, Srilanka, Vietnam, Combodia and Newguinea.

Among three cardamoms small one is the most popular species.India has the largest area (90% of the world area) and is also largest producer (70%).But of late India is facing still competition from Guatemala in the world market for the top position.

In India the cultivation of small cardamom is mainly confined to the southern states viz., kerala (60%), Karnataka (30%), Tamilnadu (10%).

Among the different spices, exported from India cardamom ranks second after black pepper. Nearly 40% of the production is exported to more than 60 countries.

Importance/ uses:

Cardamom is used for flavouring and seasoning various food stuffs, confectionery, beverages and liquors. In arab countries, beverage cardamom flavoured coffee is called 'Gawa'. It is generally offered to guests at social and religious functions. In srilanka cardamom is used in manufacturing liquors.

The essential oil of cardamom is used for medicinal purposes both in allelopathy and in Ayurveda. It is used as powerful aromatic stimulant, carminative, stomachic and diuretic. Cardamom seeds are chewed to prevent the bad bread, indigestion, Nausia and vomiting. Eating one cardamom daily with a table spoon of honey improve eye sight and strengthens the nervous system and keeps one healthy. It is believed by some people that excessive use of cardamom causes impotency.

Botany:

Cardamom is a herbaceous perennial plant. A fully grown plant is about 2-4 m height.The real stem of the plant is the under ground rhizome. The aerial pseudostem is made up of leaf sheaths. Leaves are lanceolate with dark green colour. It has shallow root system inflorescence is a long panicle with racemose clusters arising from the under ground stem but comes up above the soil. Flowers are bisexual, pale white fragrant flowers. Fruit is trilocular capsule. Flower initiation takes place in March – April and from initiation to full bloom it takes nearly 30 days; from bloom to maturity it takes 5 – 6 months. Honey bee is the principle pollinating agent.

Varieties:

Based on the size of the fruit, two varieties are broadly recognized in Cardamom

Elettaria cardamomum var major – comprise of wild indigenous type

Elettaria cardamomum var minor – comprise of all cultivated types The cultivated types are identified mainly based on the nature of panicle shape and size of the fruits as follows.

S.No	Particulars	Mysore type	Malabar type	Vazhukka type
1.			Most common and widely cultivated	Natural hybrid between mysore and malabar type
2.	Plant stature	robust	medium	robust
3.	Panicle	erect	prostrate	semi erect
4.	Capsule	bold, elongated	round to oblong	round to oblong.
5	Adaptability	high altitudes (900 – 1200 m)	low altitudes (600 – 900 m)	wide range
6	Productivity	More	Less	Less
7	Resistance	Withstand to winds	More tolerant to thrips and less susceptible to drought	
8	Fruits shape	Pods are bold and elongated	Roundish or egg shaped	Roundish to long

Improved varieties:

Coorg cardamom malabar selection – 1 (CCS – 1)(malabar type): it yields 408 kg per ha dry capsules under rainfed conditions. It was released by National Cardamom Research Station (NCRS), Appangala.

Mudigere – 1(malabar type): it yields 250 to 300 kg per ha dry capsules. It was released by regional agricultural research station, Mudigere (Karnataka).

ICRI – 1(malabar type): it yields 265 to 650 kg of dry capsule. Released by Indian Cardamom Research Institute, Myladumpara.

ICRI – 2 (mysore type): it yields 375 to 760 kg of dry capsule.Released by Indian cardamom Research Institute, Myladumpara.

PV – 1(malabar type): it yields 500 kg of dry capsule. Released by Cardamom Research Station, Pampadumpara.

SKP – 14 (malabar type): it yields 430 to 590 kg dry capsule per ha. Released by ICRI Regional station, Saklespur, Karnataka.

Climate :

Small cardamom is a humid tropical plant.It is grown under natural conditions of ever green forests at an elevation from 600 to 1500 m above MSL.Optimum elevation is 900 to 1200 m.The plant prefers temperature of 10 to 350 C and a well distributed rainfall of 1500 mm per annum.Summer showers are essential during summer i.e. February – April for panicle initiation. Otherwise it affects yield.It does not stand drought and is highly sensitive to winds. Under exposed conditions, the plant does not attain its full vegetative growth because of sun scorching. It grows luxuriantly under shade. Shade trees besides providing shade create a congenial micro climate in the plantation. It keeps the surroundings humid and cool. Moderate shade high humidity cool surroundings well distributed rainfall and wind less areas are very essential for the satisfactory performance of Cardamom.

Soils:

Grows best on well drained humus rich forest soils. Water logging and excessive soil moisture conditions are detrimental. Moisture level should be 40 to 50% of the field capacity of the soil. An ideal site is a sloppy land with good drainage.In India cardamom is grown on red, deep and good textured laterite forest soils having plenty of humus and leaf mould.Ideal pH is 5. to 6.5

Propagation:

Cardamom can be propagated by seeds, rhizomes and suckers. Out of which seed propagation is most preferred because of certain advantages over vegetative propagation.

By seed:

Propagation by seeds prevents spread of khatte disease.This is the most common and widely prevalent method. A large number of seedlings can be raised within a short time. The main disadvantage is that the progeny is highly variable with no uniformity in the yield.The seeds also do not remain viable for longer time.

By rhizomes:

Planting material of rhizomes is collected by up rooting 2 to 2 ½ year old clumps. These material are noted for their high yields. The advantage of this material is greater uniformity and earlier bearing habit compared to seedlings.One of the very serious disadvantage is that Cardamom Mosaic Disease spreads through rhizomes. Plantations raised by vegetative means are short lived. Getting adequate plant material is another difficulty. If rhizomes are used for propagation continuously. The plants tend to loose their vigour after a few generations. Due to these limitations farmers use seedlings only.

Nursery site and planting:

Seedlings are normally raised in primary and secondary nurseries. The nursery site should be selected on gentle sloppy lands, having an easy access to a water source. Raised beds are prepared after digging the land to a depth of 30-
45 cm. The beds of 1 m width and of convenient length raised to a height of about 30 cm are prepared. A fine layer of humus rich forest soil is spread over the beds. Seeds are to be collected from well ripe capsules. Immediately after harvesting, the husk is removed and seeds are washed repeatedly in water for removing the mucilaginous coating. After draining the water the beds are to be mixed with wood ash and dried in shade for a day. In order to ensure uniform and early germination, seeds should be sown immediately after extraction. If the sowing is delayed, pre sowing treatment of seeds with 25% Nitric acid for 10 min is advisable to get a quick and higher germination. One kg of capsules may produce 5000 seedlings.

Sowing may be taken up during November – January and is done in rows. Deep sowing should be avoided for better and quick germination. Seeds are mulched to a thickness of 2 cm with paddy straw or any locally available material and are watered regularly. The germination commences in about 30 days and may continue to a month or two. After germination the mulch is to be removed. Seed rate: 10 g per m^2 of nursery bed area.

An over head pandal with a height of 2 m is quite desirable. Materials like coir mat, coconut leaves or tree species which do not shed their leaves easily may be used but the coir mat is prepared as it allows uniformly filtered light.

The excess seedlings and to be thinned out of it 75 – 80 days after sowing. When the seedlings attain 5-6 leaf stage light earthing up is to be done. This would encourage better tillering and proper growth of seedlings.

Generally in Kerala and Tamil nadu the seedlings are transplanted to the secondary nursery when they attain 4 – 6 leaf stage. The beds are prepared in the same manner as that of primary nursery. Seedlings are transplanted in the secondary nursery in March – May at a spacing of 20 x 20 cm and mulched immediately beds are to be covered with an over head pandal and should be watered regularly. Recently instead of secondary nursery beds, the seedlings are also raised in poly bags containing rich forest soil.

Manuring at the rate of 90 g N, 60 g of P, 120 g of K per bed of 5 x 1 m size in 3 equal split doses at an interval of 45 days is recommended to produce healthier seedlings. The first dose of fertilizers may be applied 30 days after transplanting in the secondary nursery.

Rapid clonal multiplication technique developed by Cardamom Research Centre, Appangala:

Cardamom is propagated mainly through seeds and also through suckers each consisting of at least one old and a young aerial shoot. The suckers are commonly used for gap filling but suckers may not be available in larger numbers.

Therefore rapid clonal multiplication technique evolved by NRCS, Cardamom Research Centre, Appangala is proved to be quick, reliable and economic for production of large number of quality planting materials. The site selected for their method should have a gentle slope and must be nearer to the water source. Trenches of 45 cm width 45 cm depth and of any convenient length may be taken across the slope or along the contour at 1-8 m apart. The top 20 cm depth soil is excavated separately and heaped on the upper side of the trench. The lower 25 cm soil is excavated and heaped on lower side of the trenches all along the line.

The top soil is mixed with equal portions of humus rich jungle soil, sand and cattle manure and filled back by leaving a depression of 5 cm at the top to facilitate mulching for retentions of soil moisture. Suckers each consisting of one grown up tiller and a growing young shoot are placed at a spacing of 0.6 m in the trenches during march – October. Regular cultural operations are to be followed including a high fertilizer dose of 100: 50: 200 kg NPK / ha in 6 split doses at 60 days interval along with neem cake at 250 g per plant. Irrigation should be provided at least twice a week. Overhead pandal at a height of 3.6 m covered with coir mat or leafy twigs of any shade tree may be provided during non-rainy season, within a period of 12 months, a plant could produce at least 32-42 suckers which may yield at least 16-21 planting units i.e. about 1.5 lakh planting units per ha.

Planting:

The best season of planting seedlings or suckers is May- June after the receipt of monsoon showers. The seedlings or suckers are planted in the pits up to collar region for better growth. Cloudy days with light drizzle are ideal for panting.

Shade and shade regulation:

Cardamom is a shade loving plant (pseophyte). Shade help to regulate soil moisture as well as temperature and provides congenial micro climate for cardamom. Shade protects plants from sun-scorching, rains and winds. Shade trees provide mulch material through fallen leaves on the surface and prevent soil erosion through their root system. Excess shade is also quite detrimental and shade has to be regulated so as to provide 50-60% filtered sunlight.

In South India, many trees are available in the natural habitat to provide shade but an ideal shade tree should have a wider canopy, minimum side branching and it should not shed the leaves during flowering phase of Cardamom, so as not to affect pollination. Some of the common shade trees in cardamom estates are karimaram (Diospyros ebenum and D. elongi) , Mimusops elangi, Balangi (Artocarpus fraxinifolius), Jack, Red cedar (Cedrella toona). The temporary shade trees like Erythrina lithosperma and E. indica are the most

unsuitable as they compete for nutrients and soil moisture.In order to provide adequate light during monsoon, shade regulation may be taken up before the on set of monsoon. A two tier canopy with a height of not more than 3 m between the lower and higher canopy may be maintained. Areas exposed to western side should have adequate shade.

Manuring:

Cardamom is a surface feeder and its growing areas are usually subjected to heavy rain fall conditions, the top soil is subjected to frequent leaching, resulting in the loss and plant nutrients, even though there is annual replenishment of nutrients through the incorporation of fallen leaves of shade trees and cardamom plants. Therefore manuring is very essential.

Under irrigated conditions – 75 kg N; 75 kg P and 150 kg K per ha. Under rainfed conditions – 30 kg N + 60 kg P and 30 kg K per ha. Organic manures may be applied at the rate of 5 kg per plant.

Two split doses one during May – June for production of suckers, Second during September to October for initiation of panicle.Half dose can be applied during first year.Full dose can be applied from second year onwards.Being a surface feeder deep placement of fertilizer is not advocated. These fertilizers apply 30 cm away from the plant.

Irrigation:

Cardamom is generally raised as rainfed crop.However, it responds well to irrigation.It is necessary to irrigate the crop during dry periods to get increased yields. Since, cardamom is raised under evergreen forests and on undulated terrain, conventional irrigation methods are ot useful.

Intercultural operations:

Weeding:

2-3 weedings per year may be necessary during May- June, August – September and December – January. Paraquat @ 625 ml in 500 litres of water may be sprayed.

Mulching:

it is an important cultural operation in Cardamom. Fallen leaves at the shade trees are up rooted weeds are utilized for mulching. Mulches should be applied during November – December to reduce ill effects of drought conditions during ensuing summer.

Trashing or clearing:

it consists of removing old and drying shoots of the plant once in an year with the onset of monsoon under rain fed conditions and 2-3 times in high density plantations. The plantation is provided with irrigation facilities. Weeding and clearing may be done simultaneously during May- June and August – September.

Packing and digging:

At the end of the monsoon rains a light raking or digging of soil should be given around the pant up to a radius of 60-75 cm to conserve the moisture to the ensuing dry period particularly in low rainfall areas.

Earthing up:

After the completion of monsoon, a thin layer of fertile soil rich in organic matter may be earthed up at the base of plant up to Collar region to encourage new growth.

Cropping:

Cardamom plants start bearing in about 3 years after planting. Flowering starts in April – May and continues up to August – September. Peak flowering will be in the month of May- June. From flowering to maturity the fruit takes 5-6 months.

Harvesting:

Only ripe capsules are harvested at 25-30 days interval, the harvesting is completed in 5- 6 pickings. In most of the areas the peak period of harvest is during October – November.

Yield:

Although the Cardamom plant start bearing from 2nd or 3 rd year of planting, an economic crop can be obtained only from 4th or 5th year. Yield vary with variety and age.Optimum average yield is 50-70 kg of dry capsule per ha. Yields decline from 10th year to 12th year.

1st year of bearing – 25-50 kg per ha (dry capsules)
2nd year of flowering 50-70 kg per ha
3rd year of flowering 70-100 kg per ha

Processing:

The commercial product of Cardamom is the dried capsules. At the time of harvesting the capsules are juicy and fleshy, so they must be cured before sending them to the market.

Bleaching: Green colour of the cardamom capsules plays a vital role in the market. Green colour of the capsules can be preserved by alkali treatment. So freshly harvested cardamom capsules are soaked in 2 % washing soda (Na_2CO_3) solution for 10 min.

Drying: After bleaching, the capsules are dried either by sun drying or in fuel kilns and electric driers. The capsules are sun dried for 3-5 days. These capsules gets bleached and does not store well.Hence, now a days capsules are dried artificially in which drying is incomplete and the green colour remains in electrical drier in capsules are dried at $45 – 50^0$ C for 18 hours.

Fuel kilns: Temperature is set at $50 – 60^0$ C over night.

The capsules kept for drying are spread thinly and stirred frequently to ensure uniform drying. The dried capsules are rubbed with hands or coir mat or wire mesh and winnowed to remove any foreign matter.

Storage: Then they are stored according to size and colour and stored in black polythene lined gunny bags to retain green colour during storage. These bags are then kept in wooden chamber.

Sorting: The dried capsules are stored according to their size, colour and stored in black polythene lined gunny bags to retain green colour during storage.

LECTURE-6 : Coriander – botanical name – family – plant parts used – origin and distribution – varieties – climate – soil – preparation of land – season – seed and sowing – irrigation – manuring – intercultivation – harvesting and yield

Botanical name:	Coriandrum satuvum
Family	: Apiaceae.
Origin	: Mediterranean region.
Plant part	: Leaves and Fruits (seeds).

Coriander is cultivated both for seed and leaves. It is a minor and seed spice. It is grown for seed in Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, Orissa, Rajasthan for leaf throughout the country. In Andhra Pradesh, Coriander is grown in Kurnool, Anantapur, Cuddapah, Guntur and Prakasam, Medak and Nizamabad.

Varieties: The improved varieties released from RARS, Lam.
Lam CS 2 – Sindhu: It is a medium tall variety – more branching – seeds are straw coloured. It withstands pests and diseases – It yields about 1300 to 1400 kg per ha. The duration of the crops is about 105-110 days.
Lam CS 4 – Sadhana: It is fairly tall – good branching – seeds are straw coloured. It withstands pests and diseases – it is a dual purpose – it yields about 1400 to 1500 kg per ha – the duration is about 115 – 120 days.
Lam CS 6 – Swathi: It is a medium tall variety. Much branching. Seeds are straw coloured. It is an early and short duration variety. It yields about 800 to 1200 kg per ha. It has a duration of about 80 -85 days. It escapes Powdery Mildew disease.
Lam CS 7: It was developed as a selection from North India – It is a dwarf plant with more leaves.

Climate:

It can be grown under tropical and subtropical conditions. It require cool climate in early stages and warm dry weather at maturity. It needs dry and cool weather free from rains at flowering and fruit setting stage. Heavy rains effect the crop.

Soil:

Well drained soils, moisture retentive, humus rich soils are essential. It can be grown in sandy loams to heavy black cotton soils. Heavy Black cotton soils of Deccan and South India are particularly suited.

Land preparation:

For rain fed crop plough 3-4 times. For irrigated crop plough twice or thrice. After ploughing is complete, the land is laid out into beds and channels. Season:

For leaf purpose the crop is grown throughout the year (except March-May).For grain purpose the crop is grown during rabi season in A.P. and north and central India Kharif in Tamil Nadu and Madhya Pradesh. Some times it is grown as a mixed crop in cotton and pulses.

i) Sowing time: for rabi crop mid October to middle of the November. For Kharif crop June-July to August - September.

ii) Seed rate: it needs 12-15 kg per ha in A.P. Crush or trample the seeds gently to separate pericarps. Soak the seeds in water fro 12- 21 hours. Treat with Thiram @ 2 g per kg seed. Shade dry before sowing.

iii) Method of sowing: Broadcast sown for rainfed crop. A spacing of 3-40 cm x 15 cm is adopted for an irrigated crop. Germination starts within 10-15 days and will be over by 30 days.

Irrigation:

A post sowing irrigation is to provided. Afterwards, the crop has to irrigated at Two leaf stage, at branching stage, at flowering stage and at seed filling stage.

Manuring:

On fertile Black Cotton soils, it is not generally manured. During rabi season in A.P. 10-15 tonnes FYM; 20-30 kg N; 40 kg P_2O_5; 20 kg K_2O per ha is given as basal dose.20-30 kg Nitrogen is given at flowering under irrigated conditions.

Interculture:

Maintain weed free conditions during first 30 days. First weeding is done within 30 days after sowing. Second weeding is done before the rows close up. Inter cultivate twice with a cultivator at monthly interval.

Harvesting:

The crop will be ready for harvest in 80-120 days. Kharif crops comes to harvest earlier than Rabi

Maturity indices:

Green colour turn to straw coloured. If harvesting is delayed – seeds shattered, fruits splitted. Plants are cut or pulled. Tied in bundles. Piled in shade for drying to avoid grain shattering and loss of essential oil. After 2-3 days of shade drying, the grain is threshed, winnowed and sundried. The moisture content is reduced from 2 to 6 per cent. The cleaned, dried produce is stored in gunny bags lined with white polythene

LECTURE-7 : Fenugreek and cumin – botanical name – family – origin – economic part – importance – botany – varieties - climate – soil – preparation of land – seed and sowing – irrigation – manuring – intercultivation – harvesting and yield

Botanical name: Trigonella foenumgreakum	
Family	: Fabaceae
Origin	: South East Europe or West Asia
Plant part	: Leaves and Seeds.

Fresh tender leaves, stem are used as vegetable. Seeds are used as spice. It has high medicinal value as it prevents constipation. It removes indigestion, stimulate spleen and liver. Grown in Gujarat, Rajasthan. It occupies
3rd place in area and 4th in production among all minor spices grown in India.
Common methi – Trigonella foenumgreakum – is quick growing and produces erect shoots to a height of 40-70cm.
*Kasuri methi – Trigonella corciculata also called as Champa menthi. Champa menthi is a slow growing type and remains in rosette condition during most of its vegetative growth period.Out of these two the former is more commonly cultivated.

Common menthi		Champa menthi	
1	Quick growing habit	1	Slow growing 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

Varieties:

Pusa Early Bunching: It is a Bushy variety. 115 – 125 days, seeds are bold. Lam selection 1: It is a bushy variety, 70 days duration on Black soils under rainfed condition. It yields about 700 -750 kg per ha.

Co 1: It is a selection from TG 2336. It is a dual purpose variety. It is suitable for intercropping. It yields about 650 – 700 kg grain; 4.5 tonnes of green leaves per ha.
Rajendra Kranti : It was evolved by mass selection. Developed by RAU, Dholi. It is suitable for both pure and inter crop. It yields about 1200 – 1400 kg in 120 days.
Rmt 1 : Evolvedby RAU, Jobner. It is a pure line selection. It is moderately branched. It is tolerant to root rot and powdery mildew. It yields 1500 kg per ha in 140 days.

Climate:

It is cultivated both in tropics and temperate regions. It is a cool season crop, tolerates warm weather. It tolerate frost and freezing weather. It requires low to moderate rainfall. Heavy rains are unsuited.

Soil:

Clayey loams are better. It requires 6-7 pH. It is tolerant to salinity problem.

Land preparation: Land has to be ploughed 3-4 times. Prepare uniform beds.

Sowing:

Time: It is sown in the second fortnight of October.

Method: Broad cast over beds and rake in rainfed conditions. In irrigated conditions beds of 200 cm wide 500 – 700 cm length are prepared. Seeds dibbled in lines at 30 x 60 cm spacing.

Seed rate: 30-35 kg for rain fed crop.12- 15 kg for irrigated crop. Germinate in 3-4 days and complete in 7 – 10 days.

Irrigation:

The crop is grown as rain fed in heavy moisture retentive soils. Crop requires 3-6 irrigations. First irrigation is given after sowing seeds. Second irrigation is given after first cutting of leaves. Afterwards irrigated at 7 – 10 interval.

Manuring:

The crop is commonly grown on residual fertility. FYM @ 10-15 tones per ha may be incorporated in the last ploughing. Top dress with Nitrogen one month after sowing and after each cutting @ 10-15 kg per ha. For grain crop 20 kg Nitrogen, 40 kg P_2O_5 and 20 kg K_2O are applied as basal dose. Depending upon growth 10-15 kg Nitrogen per ha may be applied after one month.

Intercultivation:

Hoeing and weeding during the early stages of plant growth.

Harvesting:

First cut is to be given at 20-25 days after sowing. Later the crop is cut at 12-15 day interval. Afterwards 4-5 cuttings are taken. Then the plant is

uprooted at flowering an disposed. For a grain crop, 1-2 cuttings are allowed. The plant flower in 30-40 days after sowing. Pods mature within 60-90 days after sowing.

Maturity indices:

Plant start drying, pods are partially dried. Uproot the plants. Dry in the sun on threshing floor for 2-3 days. Pods are threshed. Seeds are separated by winnowing, cleaned and sun dried. Seeds are stored in gunny bags lines with white alkathene paper.

Yield:

Leaf yield is 700-800 kg per ha. Grain yield is 750 to 800 kg per ha under rain fed conditions. 1200 to 1300 kg per ha under irrigated conditions.

Botanical name:	Cuminum cyminum
Family	: Apiaceae.
Origin	: Mediterranean region.
Plant part	: Fruits (dried seed)

Introduction, uses:

Aromatic fragrance is due to an alcohol ' cuminol'. Used as a spice in curry powder. Ingredient in ayurvedic and verterinary medicines against diarrhea and dyssentry. (carminative, stomachic and astringent). Volatile oil content ranges from 2.8 to 4.7

Botany:

Annual with a height of 30-45 cm. Produces many branches. Leaves are long divided deep green. Flowers small, white or rose coloured born as umbels. Seed elongated 6 mm long and light yellowish brown.

Varieties:

RS – 1: Evolved by selection – it is an early maturing variety. It has bold, aromatic seed. It gives an yield of 763 kg per ha.

Gujarat cumin 1 (GC -1): developed by selection. Seeds bold. Yield 735 kg per ha. Duration is 105 -110 days duration. Tolerates blight and wilt.

Gujarat cumin 2:

Rajasthan zeera 19: released by RAU, Jobner. Seeds bold. Yield is 470 to 570 kg per ha. Duration 120 to 130 days. Tolerate blight.

Climate:

Tropical plant and it can be cultivated as Rabi crop in area where Low atmospheric humidity during February to march, when crop flowers and seed formation takes place. High humidity at this stage favour disease. Can be grown from sea level to 3000 m above MSL.

Soil:

Well drained, medium to heavy textured soils. On light textured soils wilt is more. Can be grown in slightly alkaline soils having a pH of 8.9.

Land preparation: Land is ploughed repeatedly to bring to fine tilth. Land is laid out into beds.

Seed rate: 8 – 15 kg per ha. Variation is due to method of sowing (line sowing or broadcasting).Soaking of seed for 24 – 36 hours is suggested to enhance the germination percentage. In line sowing, lines are spaced at 20 cm apart. Seeds are covered by fine soil. Irrigate lightly. At 5 cm height, thin the population to 15 cm spacing.

Irrigation:

First irrigation: light irrigation immediately after sowing. Second irrigation: after 8 – 10 days, after which the germination is visible. Third irrigation: after a week, to help to complete the germination. After wards: irrigate at 12-20 day interval. Irrigation at maturity of the crop should be avoided.

Manuring:

FYM @ 15 to 20 tonnes per ha is to be applied at field preparation. Nitrogen @ 30 kg per ha in two splits at 30 and 60 days after sowing is done.

Intercultivation:

At 5 cm tall; first hoeing and weeding. Later one or two hoeing or weedings.

Harvesting:

The crop matures in 100 – 120 days.Uproot the plants. Stake them in sun for drying. Threshed by beating. Clean by winnowing. Store in polythene line gunny bags.

Yield:

Varies from 500 – 800 kg per ha grains. Can be up to 1000 kg per ha under good management

LECTURE-8 : Aromatic crops – importance – essential oils – use of aromatic crops and their by – products – essential oil industry in India;
Lemon grass – botanical name – family – origin – economic part – importance – botany – varieties – climate – soil – preparation of land – importance – botany – varieties – climate – soil – preparation of land – propagation and planting – manuring – irrigation – intercultivation – harvesting – yield and oil extraction

Aromatic plants: Plants which possess essential oils in one or more plant parts.

Wood – sandal; Bark – cassia; Foliage – lemon grass; Flowers – jasmine; Fruits – citrus; Seeds – coriander.

Essential oils are secreted in oil glands.
Essential oil: Complex mixture of odoriferous steam volatile compounds, which are deposited by plants in sub- cuticular spaces, granular hairs, cell organelles, excretory cavities, canals and heart wood.

Why essential oils are produced?	1. To attract pollinating agents. 2. To repel animals or pest etc. 3. To give competitive advantage.

Uses of aromatic crops:

1. In food and flavour industry – spices and condiments
2. In perfumery, soap and cosmetics
3. Pharmaceutical and drug industries.
4. To manufacture pesticides, disinfectants due to antifungal, antiseptic and insecticidal properties.
5. In pain industry – as solvents.
6. Distilled wastes are used in manufacture of card boards, cheap paper, packing material.

Essential oil industry in India:
In India it is a cottage industry. India is the traditional producer of essential oils such as sandal wood, palmarosa, lemon grass. Indians use the plants and products in rituals, ceremonies. Some aromatic plants find place in materia medica, sandle wood, mint and fennel etc. Distillation process was mentioned in charaka and sushrita samhita (written over 3000 to 4000 years ago). India is endowed with various agro-climatic conditions, suitable for growing different aromatic plants.
Essential oil industry is not strong in India because:

1. Farmers are not aware of the significance and profitability.
2. Lack of marketing facilities.
3. High initial investment.
4. Price fluctuation
5. Competition for land domestically.
6. Lack of scientific knowledge on cultivation.
7. Deadly diseases like spike disease of sandal wood or fusarial wilt of Geranium1
8. Lack of germplasm collection and maintenance.

9. Risk, as the produce is priced on the basis of the principle.
10. Larger quantities are required.
11. Lack of testing facilities.
12. Cheaper synthetic substitutes.
13. Dearth of trained personnel.

Lemon grass

Botanical name:	Cymbopogan flexuosus
Family	: Graminae
Origin	: India (Kerala)
Plant part	: Leaves

In India, lemon grass is confined to Kerala and Jammu. Annual production of lemon grass oil is 1000 Mt.India faces stiff competition from Guatemala in world market.
Uses: 1.Chief constituent of the oil is citral, which is used in the manufacture of vitamin A tablets. 2. Oil has bactericidal, insect repellent, mosquito repellent and medicinal uses.
3. Used in soap and detergent making.4.Spent grass is good cattle feed and used in making silage. 5. Spent grass is used for preparing card boards, paper and fuel.
Botany: Genus Cymbopogan has 120 species, of which nearly 27 species occur in our country.

1. East Indian lemon grass : Cymbopogan flexuosus
2. West India lemon grass: Cymbopogan citrates
3. Jammu lemon grass: Cymbopogan pendulus.

1. East Indian lemon grass: It is indigenous to Kerala. Its oil is known as Cochin oil.
2. West Indian lemon grass: It is cultivated In Guatemala, Haiti and West Indies.
3. Jammu lemon grass: It is cultivated in Jammu and Kangra valley.It is resistant to frost. Growth period is 8-9 months. Period of dormancy being from December to February.

Varieties:
1. OD – 19: released by MAPRS, Odakkali. Belong to East Indian lemon grass. Herbage yield 50-55 t per ha.Oil yield 80-85 kg per ha.Oil recovery 1.2 – 1.5%. Citral content is 80-85 %
2. RRL – 16: Released by RRL, Jammu. Belong to Jammu lemon grass. It is frost and drought resistant.
3. SD - 68:Released by CIMAP, Lucknow. Herbage yield 50-55 t per ha. Oil yield 80-85 kg per ha. Oil recovery 1.2 – 1.5%. Citral content is 80-85 %.

Climate:

Tropical plant. Loves hot and humid climate, plenty of sun shine. Rain fall 150- 300 cm with uniform distribution. Grown mainly as rainfed crop

Soil:

Hardy and drought resistant crop can be grown on loamy to poor laterites pH 4.5 to 7.5. This crop has soil binding nature, hence useful as vegetative cover.

Propagation: Both by seeds and vegetative means through slips. Slip propagation is better in Andhra Pradesh. Seed propagation covers larger area. Seed propagation: Nursery:

Seeds are formed in November – December.

Seeds are collected in January – February.

Seeds are sown at 10 kg per 25 cents nursery per ha. Nursery beds are prepared and sowing is done during April – May. After sowing nursery beds are lightly irrigated. Seedlings will be ready in 60-75 days.

Slips: Mature clump is divided. Slips are treated for rooting. Rooted slips are used for propagation.

Planting: Land is thoroughly ploughed, leveled. Land laid into ridges and furrows. Planted with the onset of monsoon at 60 x 45 cm. 2-3 seedlings or slips are planted per hill.

Manuring:

A fertilizer dose of 100: 50: 50 kg NPK per ha per year is adopted.

Entire P and K are applied as basal. Nitrogen is applied as 2 – 3 splits first at 30 days after sowing and remaining after each harvest.

Irrigation:

High rainfall (well distributed) areas does not require irrigation. In dry and low rain fall areas , irrigate the crop at 7 – 10 day interval.

Interculture:

Keep the field weed free during the initial 3-4 months and after one month after each harvest. Plants are earthed up after every weeding and after every harvest.

Harvesting:First harvesting is done in 5-6 months under Hyderabad conditions. 90-100 days (3 months) under Kerala conditions. Subsequently cuttings are given within 3-4 months.The crop is cut 10-15 cm above the ground. Delayed or early harvest reduce citral and oil content. Discard flower stalks from time to time. Three cuttings are taken in the first year. 5-6 cuttings are taken in the subsequent years.Lemon grass is perennial, yield well from 2nd to 4th year. Plantation is economical for 5 – 6 years.

Yield:Gives 80 kg oil per ha per year. Increases from the first year to fourth year. Yield varies with season and age of the crop.

Distillation: Distilled by steam distillation. Either fresh grass is directly distilled or it is first shade dried for 72 hours and then distilled after chopping. The later method was found to be better.

LECTURE-9: Palmarosa and citronella – introduction – uses – botany – varieties – climate – soil – preparation of land – propagation - planting – manuring – irrigation – intercultivation – harvesting – yield and distillation

Botanical name:	Cymbopogan winterianus – Java citronella Cymbopogan nardus – Ceylone citronella
Family	: Graminae
Origin	: Srilanka
Plant part	: Leaves

Java type was found to be the best source of citronella oil and its cultivation has now become popular. Crop is extensively cultivated in Assam particularly in tea gardens, Karnataka and Tamil Nadu.

Uses:

1. Citronella oil is raw material for production of geraniol, citronellol, hydroxyl citronellol etc.
2. These are used in perfumery, soaps, cosmetics
3. Used in pharmaceuticals.
4. Used in flavouring industries.
5. Used as a ingreadient in mosquito repellent creams
6. Used in mosquito repellent creams.

Varieties:

1. RRL – Jor – 3 – 1970 : RRL, Jorhat. Oil has 46.2% citronellol; 28.5% gernaiol.
2. NBPGR, Delhi released two strains in Java citronella viz., IW 31243, IW 31245.
3. Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani has developed a selection namely KS – CW – SI.

Climate:

Thrive well under tropical and sub-tropical conditions. Require humid climate, abundant sunshine, well distributed rainfall of 200 – 250 cm. Long drought spells or excessive rainfall are harmful. Does not like shade, under shade growth is poor, leaf blade become hard and yield less oil. Susceptible to frost. Grow well in plains and hills up to 900 m, but best elevation is 180 – 250 m above MSL.

Soil:

Humus rich sandy loams are the best. Heavy clay and light textured soils are not good. Calcareous and water logged soils are unsuited. Soil pH 5.0 to 7.5 (optimum 6.0 to 6.5)

Land preparation: By ploughing, discing or harrowing, prepared to fine tilth. FYM plus insecticidal dust, Endrin/ Heptachlor 5% dust @ 50 kg per ha is

incorporated in the last ploughing. Apply a mixture of 2,4 – D and Grammoxone @ 25 kg per ha leave for a fortnight to check weeds. Land is laid out into beds with irrigation channels.

Propagation:

Due to irregularities in Meiosis, viable seeds are not formed. Therefore citronella is propagating through slips, obtained by dividing healthy mature clumps. Each slip should have 2-3 tillers. At the time of planting trim fibrous roots and leaves. One ha citronella produce enough planting material i.e. slips for planting in 20 ha of main field.

Planting: Best time is during SW monsoon. In A.P., planting is done during July-August. Spacing adopted is 60 x 60 cm requiring 28,000 slips per ha. If climate and soil support luxurious growth 90 x 90 cm is followed as in the upper Assam. Slips are planted vertically in 10 cm deep pits either on ridges or flat beds. As it is extremely sensitive to water logging, plant on ridges. Irrigate immediately after planting. Keep the soil moist for 3 -4 weeks, within which it gets established.

Manuring:

It is a soil exhausting crop therefore requires liberal application of manures and fertilizers. In Red soils of Karnataka, where the plant grow throughout the year, apply 200 kg Nitrogen; 80 kg P and 50 kg K. In Tamil Nadu; basal dose of 60 kg P and 50 kg K are to be applied. 125 kg Nitrogen is given in equal splits one month after each cutting. Nitrogen is given in 4 splits in North 5-6 split doses of Nitrogen is given in South. The split doses of Nitrogen are given first one month after planting and the remaining after each harvest at an interval of 3-4 months.

Irrigation:

Java citronella is grown as irrigated crop in Karnataka and A.P. It is grown as rainfed crop in High rain fall areas like Assam. 16-20 irrigations are required at 7-10 day interval.

Interculture:

Check weeds up to 3-4 months after planting and after each cutting. 3 -4 weedings are required per year. Manual weeding or weeding by running a cultivator is done.

Harvesting:

The leaves are ready for first cutting is taken 4-7 months. In Assam and Bengal first cutting is taken in 3-4 months. Subsequently harvested at 2-3 month interval. In A.P., first cutting is taken 6-7 months after planting (due to low rainfall and less growth). Three cuttings are taken per year. Possible to take four cuttings per year under good management. Should not be harvested too soon or too late affects the quality of oil adversely. Optimum interval between two cuttings is 90 days; if delayed leaves are partially dried and oil content declines. Leaves are cut 10-15 cm above ground in morning. Only leaf blade should be cut leaving leaf sheath, as leaf sheath contains only little and poor quality oil. Crop is

economical for 4 to 5 years. Once in a year clumps are cut close to ground to remove dry leaves and to maintain height.

Yield: Maximum yield is recovered from 2nd to 3rd year. Later it declines.

Year	Herbage	Oil
I	15-20 t	100-120 kg
II	20-25 t	150-200 kg
III	18-20t	150 kg
IV	13-15 t	100 kg

Oil content varies with age, climate, soil fertility and method of distillation.

Distillation: Oil is extracted by steam distillation from herbage. Distill soon after harvest. Semi dried leaves are chopped into bits. Delay in distillation affects aroma and colour of oil.

Palmarosa

Botanical name: Cymbopogan martini var motia
Family : Graminae
Origin : India
Plant part : Tender stems, leaves and flower stalks.

Palmarosa also known as East Indian Geranium. Grows wild in forests A.P, M.P, Maharashtra, Karnataka.

Uses and importance:

The oil obtained from other species Cymbopogan martini var sofia is known as the ginger grass oil. Essential oil from (Rusha or Rosha) palmarose is used to extract Geraniol and also used for inscenting soaps, perfumes, tobacco. The oil imparts rose like aroma hence heavy demand. The palmarosa oil occupies 3rd place in the export of essential oil.

Climate:

Hardy and drought resistant plant. It grows well in areas receiving 100 – 150 cm annual rainfall. Winter should be less severe. Exposure to sunlight is essential. It does not perform under shade.

Soil:

Light loamy soils with good water infiltration are ideal. Prefers well drained, neutral to alkaline soils. Can be grown in poor sandy to heavy fertile soils, saline, marginal soils also.

Varieties:

IW 31244: released by NBPGR

RRL (B) – 77 and RRL (B) 71: released by RRL, Bhubaneswar.

Trishna – Hybrid developed by CIMAP, Lucknow. Give 40% more oil and has 93% Geraniol.

Propagation:

By seed and rooted slips. First a nursery is raised. Beds are raised well prepared and well manured. Seeds @ 2.5 kg per ha is sown at 15-20 cm spaced lines.

Sowing is done during May – June. Nursery beds are irrigated daily. Germination will be completed within 2 weeks and seedlings ready in 30-40 days (15-20 cm height).

Slips: Slips are collected from elite clump. They are separated and planted during April – May. Ready for transplanting after 3 months during June- July or August - September.

Oil yield is higher with clonal propagation. Per cent of establishment is higher with seedlings.

Land preparation: Plough 3-4 times. Land is laid out into ridges & furrows spaced at 60 cm.

Planting: Planted during June- July at 45 cm apart on ridges. Irrigate immediately.

Manuring:

If grown on fertile soils, do not manure during the first year as it promote vegetative growth and reduce oil yield. In less fertile soils, basally 10 t FYM; 20 kg N; 50 kg P and 40 kg K per ha are to be applied. Top dressing with 40 kg Nitrogen each time for three times starting from 45 days after planting is to be done.

Irrigation:

If rainfall is more than 150 cm, the crop can be grown as rain fed crop. If rainfall is less than that, irrigation has to be given at 7 – 10 day interval. When the crop is fully grown, irrigate at 15-20 day interval. Yields reduced if field becomes dry.

Weeding:

Keep the field weed free for the first 2-3 months after planting and one month after each harvest. After every irrigation, soil should be loosened for improving infiltration of water and earthed up.

Harvesting:

First harvest is taken in 4-5 months after planting. Harvest 15-20 cm above the ground at the time of flowering to early seed formation stage. Subsequently the crop is harvested at 2 ½ to 3 months interval for 3-4 years. Yield: yield increases up to 4 th year.

First year: 20 kg oil per ha Second year: 60 kg oil per ha Third year: 70 kg oil per ha Fourth year: 70 kg oil per ha

Distillation: Oil is extracted by steam distillation. Herbage is shade dried for 24 hours and chopped for distillation. Oil recovery is 0.3 to 0.4%. It takes 4 hours for complete recovery of the oil.

LECTURE-10 : Geranium and davanam – introduction – uses – botany – varieties – climate – soil – preparation of land – propagation – planting – manuring – irrigation – intercultivation – harvesting – yield and distillation

Botanical name: Pelargonium graveolens	
Family	: Geraniaceae
Origin	: Cape province in South Africa
Plant part	: Leaves

It is the source of the one of the most important and costliest essential oil.

Uses:

Oil possess strong rose like odour.

Chief constituent are Geraniol 68 to 75% and Citronellol (23 – 40%).

Geranium oil is widely used in expensive soaps, perfumes and for the production of Rhodnol etc.

Demand of oil is 40 to 50 t per year. Internal production of oil is only 20 tonnes from about 1400 ha.

Types of geraniums:

There are two types of geraniums

1. Rose geranium: Pelargonium graveolens
2. Ornamental geranium: Differ from rose geranium which do not possess essential oil and used as ornamental purposes.

In rose geraniums there are two types.

i. Algerian or tunician: Plant is slender, produce dark pink flowers. It is mostly cultivated. Not suitable for wet soil conditions. Grown in Nilgiri hills.

ii. Bourbon or Reunion: Sturdy plant, produce light pink flower.Suitable for wet soil conditions. Oil quality is superior. Grown in Nilgiris and Annamalai hills.

Varieties: Kodaikanal 1: released by HRS, Kodaikanal (TNAU) give high herbage (45.2 t per ha) and oil yield (54 kg) oil contains 60 % of geraniol

Climate:

Can grow in temperate, sub- tropical and tropical climates. Flourish best in Mediterranean type of mild climate. Rainfall 1000 – 1500 mm. Sensitive to frost. Prefers sheltered warm situation. Best temperature is 20-25^{0}C.

In India it is cultivated from 1000 – 2700 m. It is grown in the hills of shevroy, Palni, Nilgiri and Annamalai hills and low altitudes of Karnataka.

Soil:

Comes up well in well drained deep, porous soil rich in organic matter. Slightly calcareous soil with a pH range of 5.5 to 6.0. It is a shallow rooted crop. It is prone to waterlogging as it aggravates disease.

Propagation: Does not set seed in India. Hence propagated through rooted stem cuttings.

Stem cuttings: Terminal stem cuttings are taken from healthy, vigorously growing plants during November. Cuttings are defoliated except top 3-4 leaves. Slant cut is made just below a node. Bottoms of cuttings are dipped in 0.3% Benlate or Bavistin 0.1% and then in Seradix powder. Planted with at least two nodes buried in the soil at a spacing of 5x5cm. Beds are hand watered after planting. As they are sensitive to hot sun, temporary shade is to be provided. Cuttings root in 30-40 days and ready for planting within 60 days after planting.
80 m x 80 m nursery is sufficient for one ha.
Land preparation: Select land on a gentle slope. Stands for 3 - 10 years, hence have a thorough preparation of land. Ploughing, harrowing and planking are to be done thoroughly for preparation of land. Manures, P and K are applied at the last ploughing and incorporated. The land is laid out into ridges and furrows.
Planting: Select sturdy, healthy disease free Rooted stem cuttings with well developed root system and a crown of leaves.
On hills: plant during May – June; On plains: December – January.
Dip the cuttings in 0.1% Bavistin and plant on ridges 60 x 60 cm. Irrigate on alternate days for a month and later at weekly intervals. Plants establish within two months.

Manuring:

10-20 t of FYM; 35-40 kg N, P2O5 and K2O are applied as basal dose. Top dress with 30 and 40 kg N per ha is recommended at 30 and 90 days after planting. 35 kg Nitrogen per ha is applied at the end of each harvest. Altogether Nitrogen is given in 6 splits per year. The above dose is repeated again.

Irrigation: The crop is raised as an irrigated crop. It is a shallow crop hence needs frequent irrigations.
Interculture: Keep the field weed free during the first 2-3 months after planting and up to one month after every harvest. Weed with minimum soil disturbance and for root.
From second year, soil should be worked to provide aeration and induce plants to produce more root suckers.

Harvesting:

Geranium comes to first harvest in 4-5 months after planting
Later harvesting is done at the beginning of flowering season. Harvesting is done when the leaves turn light green in colour. Lemon like odour changes to that of rose.

Subsequently the crop is harvested once in 3-4 months for 3-4 years. Tender twigs and terminal portions are harvested for oil extraction. After each harvest spray 0.1% Bavistin or Benomyl, fertilized and irrigated immediately.

Yield:

Yield depends on total population in the field. A minimum of 25,000 plants must be maintained in a hectare area. Herbage yield is 30-40 tonnes per ha per year. Oil yield is 30-40 kg per ha per year. Oil content ranges from 0.1 to 0.15 %

on fresh weight basis. Oil content is influenced by stage of crop and period of harvest. Oil content is higher during summer (April to June). High humidity and rains at harvest lower the oil yield.

Terminal portion with 6-12 leaves contain more oil than the middle or basal portions.

Distillation: Oil can be extracted by Steam distillation of freshly harvested terminals.

Davanam

Botanical name:	Artemesia pallens
Family	: Asteraceae
Origin	: India
Plant part	: Tender stems with flower panicles

It is an aromatic herb. It is grown traditionally in India to include tender shoots in garlands. It is less known to the perfumer because of high price of oil (Rs. 15000 – 18000 per kg). The chief chemical constituent of Davanam oil is Davanone. India is the only country where Davanam is under cultivation. Only in Karnataka it is grown for essential oils. In A.P., it is grown in Krishna, Cuddapah, Chittoor and Guntur districts.

Botany:

It is an annual herb, erect growing plant. It reaches a height of around 45 – 60 cm.

The leaves are characteristically bluish green in colour. The inflorescence is axillary with very minute flowers

Climate:

It requires bright sun shine, moderate rainfall, winter without fog. It prefers a temperature range of 20 to 30^0C with least diurnal differences. Cool weather is preferable for oil production November to March). It can be rationed upto April. At blooming / harvesting, there should not be any showers/ cloudy weather, otherwise oil yield is adversely affected.

Soil:

It comes up well in rich loams. It can be grown in sandy, red, alluvial soils. Fertile alluvial soils are the best.

Propagation:

It is propagated through seed. Seeds are very minute 1 gram weighs 6000 seeds. Seeds from current crop are selected for sowing. One year old seeds are more preferable, but seeds more than one year do not germinate. They are non- viable.

Nursery:

Raised beds of 2 m long and 1 m width are preferred. FYM @ 10 kg per bed is mixed well in the soil. Seed rate is 1.5 kg per ha in 500 m^2 nursery. High seed rate is to allow losses due to poor germination, damping off, ants and to select healthy seedlings.

Sowing:

Seeds are mixed with sand in 1:11 ratio. Seed bed is kept moistened in a moist cloth for 2-3 days 48-72 hours. Pre germinated seeds are sown on the beds. Beds are dusted with 5% BHC powder against ants and termites, flooded with water, seeds sown evenly on the wet beds. Beds lightly covered with fine sand to avoid washing off. Irrigate twice a day till the completion of germination and once a day afterwards. Beds covered with dry grass during the day and removed in the evenings. Seeds germinate within 3-4 days. When the seedlings are 2-3 cm long, shade is discontinued and beds watered once in a day.

Time of sowing:

Season is unimportant when grown for garlands in which case harvested at 2 months age. Season is important when crop is meant for oil, in which case, harvested at flowering i.e. 4 months age. At this stage flower stalks contain maximum oil.

For oil purpose the crop is sown n September – Octber and transplanted during November – December. By February- March, crop is harvested and ratoon extends upto April – May.

Land preparation: Land is ploughed thoroughly and laid out into beds.

Planting: Irrigated one day in advance of planting. 6 to 8 week old seedlings of 10-15 cm height are transplanted on wet beds at 15 x 7.5 cm. Beds are irrigated every day for the first 10 days and thereafter once in 2 days.

Manuring:

As basal dose 50-60 tonnes of FYM, 40 kg of P2O5 and K2O each per ha Nitrogen @ 160 kg per ha in three splits is to be top dressed. Nitrogen @ 30 kg per ha is applied at 10 days after transplanting for ratoon crop. For the main crop first split is given 10 days after transplanting (DAT), Second split is given 15 DAT, Third split is given 15 DA second split.

Irrigation: It requires frequent irrigations. Soil should not become dry, otherwise oil yield is affected.

Weeding:

Since close spacing is adopted, crop do not allow weed growth. Two weedings for the main crop once at 10 days after transplanting and the second before the crop covers interspaces. In case of ratoon, remove weeds after 10 – 15 days after harvesting.

Harvesting:

First flower bud appear, 2-3 months after transplanting by the end of January. Crop is harvested for obtaining good yield at maximum flowering and quality oil. This stage is normally reached by the end of Februay. Harvest the crop with sickle at 10 cm height from the ground level. Fresh sprouts appear and one more crop i.e. ratoon is taken up after two months i.e. April – May.

Yield:

Herbage yield is 10 t per ha. Oil yield is 10 kg per ha

Oil extraction:

Herbage is shade dried for 2-3 days and extracted by steam distillation.

LECTURE-11: Vettiver – introduction – uses – botany – varieties – climate – soil – preparation of land – propagation – planting – manuring – irrigation – intercultivation – harvesting – yield and distillation

Botanical name:	Vetiveria zizanioides
Family	: Graminae
Origin	: India and Srilanka
Plant part	: Roots

Vetiver oil, enjoys world wide reputation, being one of the finest oriental perfumes. Use of vetiver oil is known in India, through several centuries. Vetiver is found wild throughout plains and lower hills (1250 m) in India, Burma, Srilanka. Vetiver is cultivated in Kerala, Tamil Nadu, Rajasthan, Uttar Pradesh and Andhra Pradesh.

Uses:

The vetiver oil is extracted from the roots of grass. Oil from roots is used for soap making, perfumes and attars. Roots are used to make mats, brooms, screens, mattresses along with bamboo. Roots used in pharmaceuticals. Leaves are used as roofing material and for mulching.

Varieties: Basically there are 2 main types in vetiver viz.,

1. Seeding type: They grow wild in North India. Oil from some of the North Indian types has superior aroma. Ex. Akhila, Bharatpur, Musanagar.
2. Non seeding type: They grow in South India.

IARI developed three selections, which give double root yield

Two hybrids Hybrid 7 and 8 superior in root and oil yield.

In Kerala – ODVI 3 hybrid is a superior variety than the local type Nilambur

Climate:

Vetiver survives under any agro climatic conditions. It prefer mild climate for the best performance. It is cultivated in 100-400 cm rainfall in South India, as well as in Bharatpur area in Rajasthan receiving scanty rain. Under temperate or warm winter hilly areas growth is stunted. Shade has unfavorable influence on root growth. It stands well against winds and storms.

Soil: It thrive well in the dry lands of West and sandy soils of East. It grows well in marshy areas of Bharatpur. It can withstand prolonged dry spell as well as water stagnation. Loose sandy soils are most suited. Roots can be easily pulled. Compact heavy soils restrict root growth and pulling out of roots is difficult.

Land preparation:

Plough repeatedly in all directions to achieve fine tilth up to 60 cm. All vegetation, roots, tubers are thoroughly removed. Level the field, lay out into beds of 100 square meters. In these beds, ridges and furrows are laid out. Propagation:

Vetiver can be propagated through tillers and slips. Tillers take long time, hence slips are preferred. Collect slips from previous crop.

Planting:

Best time is June- July, after the monsoon showers. Slips of 15-20 cm long are separated from clumps. Top portions are cut. 2 to 3 slips are planted per hill to get a thick stand at 5-8 cm depth in furrows. Spacing 22.5 cm x 22.5 cm. One ha require 1,50,000 -2,25,000 slips. Planting should be done when there is adequate soils moisture.

Irrigate immediately after planting. Give irrigations up to 10-15 days till slips establish.

Manuring:

Apply Ground nut cake, FYM, wood ash etc, which enhance root yield and and oil yield. Trials at Odakkali indicated application of organic manures is optimum for high yields. In North India, 20 kg N per ha is applied after 2 months of plantings

Inter culture:

Weed control is the most important. Weed roots intermingle with crop roots and yield and quality is affected. 3 to 4 weedings are necessary in the first year.2-3 weedings are taken up during second year.

Harvesting:

Roots for distillation will be ready for harvesting 18 months after planting. Roots expose to hard surface when the skin is peeled off, thick, hard long and wiry. Give better taste when chewed, will give more oil. Young tender thin roots give poor quality oil. Oil from the old thicker well developed roots is of better quality and darker colour.

Harvesting time: Oil content and yield are less during rainy season as the oil is diffused into soil. Plant produce new roots during rainy season oil synthesis is reduced. Harvesting roots during dry periods is more preferable.

Harvesting method: Above ground portions are cut to 15 to 20 cm above the ground. Clumps are uprooted by digging forks. Soil is dug up to 30 to 40 cm to get 50% roots.

Clumps are beaten to remove adhering soil and roots separated from the stem portion with sharp knife. Clean the roots thoroughly in running water and send for distillation.

Yield:

5-6 tonnes of roots per ha. It gives 15 to 16 kg of oil and 1 to 1.5% oil on dry weight basis. The oil contains 65 to 75 per cent Veteverol.

Distillation:

Oil is extracted by steam distillation. Herbage is steeped in water for 12 hours, chopped to 5-10 cm long bits and distilled.

LECTURE-12 : Plantation crops – introduction and importance in Indian economy;

Areca nut – botanical name – family – origin – importance – botany – varieties – climate – soil – raising of planting material – preparation of land – planting – manuring – irrigation – intercultiation – cover cropping - intercropping – harvesting – yield and processing

Plantation: A large contiguous area in which a forest crop raised either by direct sowing or transplanting.

Plantation crop: In original sense the term plantation refers to a forest crop raised artificially either by direct sowing or planting.

In horticulture sense the term plantation crop refers to a woody perennial crop grown on a large contiguous area, managed by an individual or a company, the produce of which is consumed only after processing.

Requirements of a crop to be categorized under plantation crop:

1. It should be a woody perennial (palm, tree, shrub or vine).
2. It should be grown on a large contiguous area (estate or plantation)
3. It should be managed by an individual or company.
4. The produce is suitable for consumption only after processing.

Estate or plantation: The term estate or plantation refers to a large scale agriculture unit, usually of a single crop or a large contiguous area usually under a single crop managed by individual or company.

Plantation crops are cultivated on an extensive scale. Produce has to be processed before they are put to use.They are high value commercial crops. All are perennials. Arecanut, Cacao, cashewnut, coconut, coffee, oil palm, betelvine, rubber and tea are some of the plantation crops.

Economic importance:

1. They are export oriented. Ex: cashew nut, betel vine, tea comprise of 75% of total export earnings from the export of all agricultural produce.

2.They provide gainful employment: Cashew cultivation employs 2 lakh people, processing industry employs 3 lakh people. Arecanut crop employs 6 million people. Coconut crop employs 10 million people. They occupy only 2% of total cultivated area, but generate 36,000 million rupees per annum.

3. They support many ancillary industries.
4. They conserve soil and eco system.
5. Tea and coffee are cultivated over hill slopes; cashew nut is cultivated on waste lands. They protect soil from erosion losses.

Geographical distribution of plantation crops:

Almost all plantation crops are restricted geographical distribution to the tropics. Certain plantation crops are sun loving (coconut, cashew nut, rubber, oil palm, arecanut), others are shade loving (coca, tea, coffee, betelvine).

In general coconut and cashew nut are cultivated in coastal belt. The sun loving plantation crops should always be raised under mono culture as sole crop, while the shade loving plantation crops (coca, coffee) may be raised as inter crop in the inter spaces of grown up sun loving plantation crops(coconut, oil palm and

arecanut) or grown along with shade or nurse trees (silver oak) to have either shade (coffee, tea) or support (betelvine) or both (betelvine)

Areca nut

Botanical name: Areca catechu	
Family	: Palmae
Origin	: Islands of Indian Ocean (Malayan archipelago and other east Indian islands)
Plant part	: Kernel

There are four important species under Commercial cultivation is confined only to India, Bangladesh and Srilanka. Areca genus. A. normanbyii, A. triandra, A. macrocarpa and A . catechu., out of which only Areca catechu is commercially cultivated. Its cultivation dates back to pre Christian era in India.

Cultivated for kernel, which is chewed. In India it is extensively grown in Kerala occupying 68% area, Karnataka occupy 28% are and the rest of area is spread out in Tamil nadu, Assam, Orissa and shore areas of A.P. Kerala, Karnataka and Assam comprise 90% of the total area and production. In A.P., very meager area of 200 ha is under Areca nut. Arecanut has three alkaloids namely Arcoline, Arcolidine and Guracine. They help in control of worms in digestive tract. In India it is being used for chewing along with Betel leaf and offerings in ceremonial function.

Botany:

It is a tall, slender palm. The stem is known as cuadex. It reaches a height of 15-20 m. It has unbranched smooth cylindrical stem. The male and female flowers are present in the main rachis and secondary and tertiary rachises. It is monoecious, inflorescence is spadix, enclosed in spathe. Male and female flowers mature at different stages encouraging cross pollination. It is a cross pollinated crop. Only 50% of the female flowers are fertilized. Fruit is one seeded berry. it is oblong in shape which is enclosed in a scarlet coloured or yellowish or orange coloured husk. The fruit is mono locular in nature. It takes 35 – 47 weeks for maturity (9-11 months).

Varieties: Indigenous varieties:-

Thirthahalli (Karnataka)

Sreevardhan (Kerala)

Mehatinagar (Maharastra), Sreechakra (from coastal maharastra)

Kahikuchi (Assam)

Introduced varieties: CPCRI, Kasaragod and its regional research centre at vital in karnataka improved certain strains of A. catechu. They introduced the following strains from various countries. Mangala, Sumangala and Sreemangala.

Mangala:- introduced from China. It is a semi tall variety. It flower early in 3rd year it self. Male phase is extended and overlaps with female phase leading to selfing. Higher fruit set leads to higher yield of around 10 kg ripe nuts per palm per year. Yield is 70% more than locals. Fruit is dark orange coloured and weight
48 to 50 grams each with 11.5 to 12 grams of nut.
Sumangala:- Selection from Indonesia. It is prolific than mangala. It yields around 17.5 kg nuts per palm at 10th year.
Sreemangala:- It is a selection from Singapore. It is a prolific yielder. It yields around 16.5 kg per palm at 10th year.

Climate:

A tropical plant. It grows well up to 1000 m above MSL. It require well distributed rainfall. Cultivated mainly from 280 N and S latitudes. Requires moist climate, hence grown along with Mango, Jack and Coconut. It cannot withstand extreme temperatures with wide diurnal variations. Optimum temperature is 15 to 380 C. Banana is intercropped to keep down the temperature.

Soil:

Deep well drained soils are suitable. Laterites and red loams and alluvial soils are preferable. Does not stand water stagnation.Drainage is more important in high rainfall areas.

Planting material:

Propagated through seed. Elite mother palm should have
1. Higher productivity 2.Higher percent of fruit set 3.Precocity 4. It should be able to transform 50% of the female flowers to nuts 5.Stability in yield. 6. Nuts should be fully ripe, should be heavier (above 35 g) to get high percentage of germination and high vigour.

Medium to heavy nuts are selected and are soaked in water. Lighter nuts which float on water are rejected and heavier nuts are used for multiplication. Seed nuts are sown immediately in the nursery beds raised in sandy soils. Two to three month old sprouts with 2 to 3 leaves are transplanted to the secondary nursery. Secondary nursery beds of 150 cm width and convenient length are prepared. Sprouts are planted at 30 x 30 cm spacing with the on set of monsoon. Provide shade by erecting pandal or by growing banana. Beds should be supplied with basal dress of well decomposed cattle manure @ 5 t per acre. Irrigate the beds provide facility for draining excess water. Weeding, mulching should be done as per the requirement. Seedlings are transplanted at
12-18 months old.

Seedlings with good number of leaves (5-7) and having minimum height are selected as they are high yielder. Seedlings lifted along with a ball of earth.

Land preparation:

Land is prepared by repeated ploughing. It is leveled. Irrigation and drainage channels are laid out. Pits of 90 cm cube are dug at 2.7 m spacing. Pits are filled with compost, tank silt up to 50 cm from the bottom. Banana can be raised to give protection from sun scorch.

Planting:

Seedlings are planted from the beginning of monsoon up to the end of rainy season. In kerala – on well drained soils – planted during May- June.

on clay - planted during August – September.

In Tamilnadu – banana is planted in June – July. Arecanut is planted in the month of October.

The seedlings are protected from sun scorching. Rows may be arranged by North – South line, deflected at 35 degrees towards west. On south, south west side tall quick growing shade trees may be raised to provide shade.

Irrigation and drainage:

Palms should be irrigated once in 3-5 days depending on soil type and climate. Arecanut is sensitive to water logging. Adequate drainage should be provided, particularly in heavy rainfall areas. Drainage channels may be laid out at every two rows with 30 cm depth.

Manuring:

100 grams: 40 grams: 140 grams of NPK and 12 kg green leaf and 12 kg compost for bearing palm is recommended in Kerala. Organic manures are applied once in September – October. Fertilizers are applied twice in September – October and February for irrigated areas. Once in March – April for rainfed areas. 1/3rd of the above dose should be applied during the first year. 2/3rd of the above dose should be applied during the second year. Full dose should be given from 3rd year onwards. First split is broadcasted around the base after weeding and forked in. Second split is given in a trench (20-30 cm) dug around palm at 75 –100 cm radius from the base of the palm.

Interculture:

Light digging at the end of monsoon (October – November).Weeding periodically to avoid competition and to keep the garden clean.

Cover cropping:

On slopes cover cropping is to be done to prevent soil erosion, weed growth, and to add organic matter. Legumes such as Mimosa invisa, Stylosanthes gracilis and Calapogonium mucanoides. Cover crops sown at the beginning of monsoon and applied in September.

Intercrops:

Arecanut palm has long pre bearing period (5 – 7 years). Intercrops like Banana, Tapioca, Dioscorea, Sweet potato, Ginger, Turmeric, Elephant foot yam. Mixed cropping with Cacao, Pepper, Pineapple, Betelvine, Nutmeg and Clove.

Harvesting:

Harvested at different stages of maturity for different purposes.

I. For preparation of chali supari:- Fully ripe, 9 month old fruits of yellow to orange red colour are harvested from December to March.

II. For preparation ofKalipak supari: – fruits of 6-7 month old are harvested from July to December.

Yield: Average yield is 10 kg per palm per year at 10th year. Average yield in India is 1250 to 1500 kg per ha.

Processing:-

I. Chali supari:-

It is a dried nut. For preparation of chali supari 9-10 months old nuts at full maturity or ripe stage are harvested. Ripe fruits are sun dried for 35 to 40 days. Husk loosens from the kernel. Nuts are dehusked and kernels are cut into two halves transversely. In other method the nuts are cut longitudinally along with husk and again dried in open field. With the help of a sharp pointed sickle the kernel is separated out and cut transversely. Again these kernels are dried to reduce the moisture percentage to 10-12%. These kernels are cut into smaller pieces or whole kernels are used for marketing process. The products are called chali supari. Chewed along with betel leaf, preferred in North, North East, West and Central India.

II. Kalipak supari (Kempadike):-

This product is more popular in Karnataka, A.P. It is mostly used for sweet supari and also for ritual offerings. Nuts are dehusked. They are cut into two halves transversely. Boil with water and dilute extract of previous boiling (kali). Kali or cheguru is prepared by boiling broken pieces of chali supari, herbs and other tuberous roots available in forest. By repeated boilings a black colour syrup is obtained in which the selected nuts are transferred and boiled till they reduce its volume or its weight to 1/4th level. Milk is added to the boiling medium to remove astringency. Boiled kernels are sun dried for 7-8 days and graded according to size and quality. Preferred in Karnataka, Tamil nadu and Andhra Pradesh.

LECTURE-13&14 : Cacao – botanical name – family – origin – importance – botany – varieties – forestero, criollo and other types – climate – soil – propagation – preparation of land – planting – irrigation – weeding – mulching – pruning – intercropping – cover cropping – manuring – harvesting – yield – processing – uses

Botanical name:	Theobroma cacao
Family	: Sterculiaceae
Origin	: Tropical south America
Plant part	: Beans

Importance:

The roasted product of the dried beans is called as Cacao nibs which are used for the manufacture of various products. When cacao nibs are ground, the resulting product is called chocolate liquor or mass. It has around 55% fat. The fat that is pressed from chocolate liquor is termed as cacao butter. It is mainly used for the manufacture of chocolates, in pharmaceutical preparations and soap making. After pressing out the fat the resultant product with reduced fat content (around 22%) is called cacao powder. For preparation of chocolates cacao power is mixed with cacao butter and sugar with a definite ratio. Milk chocolates are prepared by adding milk to the above mixture.

Varieties: Commercially cacao has two major varieties, Criollo and Forestero which differ in many aspects as follows:

S.No	Character	Criollo	Forestero
1	Cotyledons	Plumpy and white when fresh and turn cinnamon coloured on fermentation	Flat and purple when fresh and turn dark chocolate brown on fermentation.
2	Pod colour	dark red	yellow
3	Other pod characters	Rough surface, ridges prominent, pronounced point and thin walled.	Smooth, inconspicuous ridges, thick walled, melon shaped with Rounded end.
4	Flavour and aroma	Bland flavour	Harsh flavour, bitter taste.
5	Duration of fermentation	3 days	6 days
6	Adaptability in India	Poor adaptability	Good adaptability
7	Yield	Less yield potential and Hence discouraged for commercial cultivation.	high yielding and hence recommended for commercial cultivation.

Other commercially cultivated types of cacao include

i. Trinitario from Trinidad which is said to be a hybrid between Criollo and Forestero with highly variable pod characters.

ii. Ameonado, a Forestero type bean with a melon shaped pod, cultivated in West Africa.
iii. Amazon, a relatively new type collected from the Amazon forests which has got vigour and high yield.
CPCRI, Kasaragod recommends some selections introduced from Malaya viz., I-21, II-11, II – 18, II – 67, III-5 and III- 101 for commercial cultivations since they are high yielding and have beans weighing more than one gram.

Climate:

Cacao is a crop of humid tropics requiring well distributed rain fall.A minimum of 90 to 100 mm rainfall per month with an annual precipitation of 1500 to 2000 mm is ideal. However, it can also be grown in other regions by supplementing rainfall with irrigation during dry periods. However, for successful cultivation the dry months should not exceed 3 to 4 months. This limits the distributions of cacao to within 20^0 latitude on either side of the equator. Cacao tolerates a minimum temperature of 15^0 C and a maximum of 40^0 C, but temperature around 25^0C is considered as optimum.
It can be grown in place from sea level up to an elevation.

Soil:

Cacao grows on a wide range of soils but loose soils which allow root penetration and movement of air and moisture are ideal. It should retain moisture in the soil during dry season as cacao requires regular supply of moisture for proper growth. Though cacao can be grown in soils with pH range from 4.5 – 8.0 it thrives better in neutral soil.

Planting material:

Cacao can be propagated from seeds or vegetatively from buds and cuttings. However, vegetative propagation is used only for experimental studies. Seed pods may be collected from trees yielding 80 or more pods per year with pod weight 350-400 g. fresh beans from such pods should be used for sowing, as cacao seeds lose their viability soon after they are taken out of pods. Before sowing, the seeds are rubbed with dry sand or wood ash to remove mucilage. The beans are planted with their pointed end upwards, either in plastic bags (25 x 15 cm size, 150 gauge) or in raised beds. If sown I beds young seedlings are usually transplanted into polythene bags after about two weeks of germination. The seedlings are ready for transplantation to the field after about 3 to 4 months or they attain a height of 30 cm.

Cacao can be also propagated vegetatively through cuttings, soft wood grafting, forkert method of budding etc., but there are limitations at present for adopting vegetative propagation on commercial scale.

Establishing plantation:

Cacao, whose natural environment is the lower storeys of the forest, requires shade when young and also to a lesser extent when grown up.

Young cacao plants grow best with 45 per cent full sun light.Therefore, it can be grown well in the partially shaded conditions prevailing in the arecanut and coconut gardens in our country or as a pure plantation in forest lands by thinning and regulating the shade suitably.It is planted at a distance of 2.5 – 3.0 m both between and within rows, either in the beginning of the monsoon, in May
– June or at the end of the south west monsoon, in September.

Cacao under arecanuts and coconuts is the cropping systems which can be adopted advantageously in kerala, Karnataka and Tamil Nadu. In arecanut gardens where the spacing is 2.7 m x 2.7 m cacao is inter planted in alternate rows at a spacing of 5.4 m 2.7 m. In coconut gardens, it can be planted
2.7 m apart in a single row.Under the double hedge system, cacao is planted in two rows adopting a spacing of 2.7 m within the row and 2.5 m between rows of coconut planted at a normal spacing of 7.5 m x 7.5 m .

Manuring and irrigation:

An annual application of 100 g N, 40 g Phosphate and 140 g of K per tree per year in two split doses is recommended. During the first year of planting, the plants may be given one third of the above dose, while in the second and third year and above, two third and full dose of fertilizers are applied respectively.

The fertilizer is applied in two splits, the first dose in March – April and the second dose in September – October. Fertilizers may be applied uniformly around the base of the tree up to a radius of 75 cm and forked and incorporated into the soil. Cacao plants require continuous supply of moisture for optimum growth and yield. During summer the plants will have to be irrigated at weekly intervals. If adequate water supply is not ensured in summer months, the yield will be reduced and under mixed cropping systems, if there is severe drought the yield of both the crops may be affected.

Pruning:

The cacao trees should be pruned regularly to develop a good shape.
Cacao grows in a series of storeys. The chupon or vertical growth of the seedlings terminates at the jorquette, where four or five fan branches develop. Further chupon develops just below the jorquette and continues its vertical growth till another jorquette forms and so on. When the first jorquette develops at a height of about 1.5 m, the canopy will form at a height convenient for harvesting and other operations. Hence, all the fan branches arising from the main step are nipped off up to a height of about 1.0 to 1.5 m or cut in the initial years of their growth. It is desirable to limit the height of the tree at that level by periodical removal of chupon growth. A second jorquette may be allowed to develop, if the first one formed was very close to the ground. Generally, 3- 5 fan branches are developed at each jorquette. When more fan branches develop on or two weaker ones may be removed. The branches badly affected by pests and diseases also should be removed.

Harvesting:

Cacao flowers from the second year of planting the pods take about 140 to 160 days to mature and ripen. Each pod will have 25 to 45 beans embedded in white pulp (mucilage). Generally cacao gives two main crops in a year i.e. September – January and April – June, off season crops may be seen almost all through the year, especially under irrigated conditions. Only ripe pods have to be harvested without damaging the flower cushion, at regular intervals of 10 to 15 days. The pods are harvested by cutting the stalk with the help of a knife. The harvested pods should be kept for a minimum period of two to three days before opening for fermentation. For breaking the pods cross wise, wooden billet may be used and the placenta should be removed together with husk and the beans are collected for fermentation. A pod will have about 30 to 45 seeds covered with pulp or mucilage.

Processing:

1. Fermentation:

The beans should be fermented to develop chocolate flavour, reduce bitterness, loose viability, remove the mucilage coating and to enable the cotyledons to expand.Fermentation is done immediately after collecting the beans from the pods. There are two popular methods of fermentation using either trays or boxes.

i. Box method:

In this traditional method, boxes of various shapes and sizes are used. The smallest one has the measurements of 60 cm x 60 cm x 60 cm and will hold about 150 kg wet beans. The bottom of the box has a number of holes of 1 cm diameter spaced at about 10 cm apart. Three such boxes are arranged in a row so that beans can be transferred from one box to the other. The beans are placed in the top most and covered with banana leaves or gunny bags. After 2 days, the bean should be uncovered and transferred into the second box and then to the third box after another 2 days. On the sixth day, fermentation is completed and beans can be taken out for drying.

ii.Tray method:

This method is used only for fermenting forestero cacao beans. The normal size of the tray is 90 cm 60 cm x 12 cm with a capacity to hold about 40 kg wet beans. The bottom of the tray is either slotted or drilled to make 1 c holes on a 4 cm square pattern. A minimum of 4 trays are needed for successful fermentation. All the trays are filled with beans. The top most tray is covered with banana leaves or sacks. The fermentation is faster here and is completed in about 4 to 5 days. This method is more convenient for large growers as the trays can be easily handles and no mixing is required and the period of fermentation is less.

iii.Basket method:

Bamboo or cane basket of suitable size having one or two layers of banana leaves at bottom to drain the sweating is filled with the beans and the surface is covered with banana leaves. After one day the basket is covered with thick gunny sacks. The beans are mixed thoroughly on the third and fifth days and covered with gunny sacks. The fermentation will be completed at the end of the sixth day and the beans are withdrawn for drying.

2.Drying:

After the fermentation, the beans can be dried by sundrying or artificial drying as the fermented cacao beans have considerable moisture (55%). Sun drying is good as it gives superior quality produce when compared to artificial drying. The fermented beans are spread in a thin layer over a bamboo mat or cement floor and dried for 5 to 6 days. The beans are to be stirred from time to time for uniform drying. The moisture content of well dried beans is around 6 to 7 per cent. During the monsoon period, artificial drying has to be adopted. Electric ovens or conventional type drier could be used. The duration of artificial drying varies from 48 to 72 hours at 60 to 70 degrees Celsius. The drying of beans at high temperature should avoided as it results in low quality end product. Slow drying in the initial stage has given better quality beans. Well dried beans when shaken should give a metallic sound.

3.Grading and Storage:

The flat, shriveled, broken and other extraneous materials are removed. The cleaned beans are packed in fresh polythene –lined (150-200 guage) gunny bags. The bags are kept on a raised plat form of wooden planks. The beans should not be stored in rooms where spices, pesticides and fertilizers are stored as they may absorb the odour from these materials.

LECTURE-15&16: Cashew nut – botanical name – family – origin – introduction – importance – botany – climate – soil – varieties and propagation – preparation of land – planting – irrigation – manuring – intercultivation – intercropping - training and pruning – cropping – harvesting – yield – processing

Botanical name: Anacardium occidentale	
Family	: Anacardiaceae
Origin	: Tropical south America (south east brazil)
Plant part	: Kernel

Introduced into Malabar coast of South India in 16th century by Portugase. It is grown up to 28^0 N and S latitudes. India stands first both in Area and Production. Brazil, Tanzania, Mozambique, Kenya and Nizeria are other important cashew nut producing countries. Cashew gained commercial importance in 1920s. India produce 40% of raw nuts and exports 90% of the world produce. Two lakh people were engaged in Cashew industry. India imports
90,000 tonnes of raw nuts and export 50,000 tonnes of kernels. Export earnings from Cashewnut constitute 2% of total earnings from Agricultural commodities. Major cashew growing states in our country is Kerala, Karnataka, Tamilnadu, Andhra Pradesh, Maharashtra, Orissa and Goa. Important cashew growing districts in Andhra Pradesh are Guntur, Krishna, East and West Godavari, Srikakulam, Vizayanagaram, Nellore, Prakasam.

Importance:

1. Cashew nut is rich in proteins and vitamins A, B and E.
2. Kernel give 40% oil.
3. Testa rich in tannins used in leather industry testa with kernel pieces used as poultry feed.
4. Cashew apple is a rich source of Vitamin C (5 times more than Citrus), contain 10-12% sugars.
5. In Goa Feni (liquor) is prepared from Cashew apple.
6. Apple is dried and powdered into a meal and used as animal feed.
7. CNSL is a bi product. It is phenol. It is used for resins, varnishes, paints, insecticides, break linings, wood preservatives etc.

Botany:

It is an ever green, low spreading tree and it grow up to 10-15 m. It has strong tap root and extensive lateral roots (Rhamniferous root sykstlem). It has intensive and extensive types of branching. Intensive shoot grows to 25 to 30 cm terminates into a panicle and 3-8 laterals arise from below the panicle. It leads to bushy growth. Extensive shoot grows to 20-30 cm. bud sprouts below and leads to further growth. Continues for 2 to 3 years without flowering. It is a spreading tree. High yielders have more than 60% intensive branches whereas low yielders have less than 20% intensive branches. It is a polygamous monoecious tree. 95% of them are staminate flowers and the rest are

hermaphoridites. Flowering occurs in three phases i.e. male, mixed and female phases. Pollination is by insects and by wind. 85% of perfect flowers are fertilized of which only 4 to 6% reaches maturity. Cashew apple is fleshy peduncle. Nut is the real fruit.

Nut is a drupe. Kidney shaped and it is grey in colour. Nut vary in size, shape, weight and shelling percentage.

Climate:

It is a hardy tropical plant. It grows between 28^0 N and South latitudes. It grows to 1000 m elevation. It is profitable up to 600 m. It requires a well distributed annual rainfall of around 500 mm. It can stand 300 to 400 mm. Rainfall should spread over 5-7 months with 3-4 months of dry period before flowering. It requires 15 to 40 ^{0}C temperature. Mean annual temperature should not be less than 20 ^{0}C. It is sensitive to cold. If Relative Humidity is less than 10%, leaves scorched and fruits drop. Excess humidity favour incidence of pests and diseases. Proximity to sea is favourable (160 km)

Soil:

Cashew is raised on laterites, red soils and coastal sands. In the East coast it is grown on porous and poor sandy soils.In the west coast it is grown on laterites. Sandy loam soils having 3 meter depth are ideal for cashewnut cultivation. The crop cannot stand waterlogging but can stand drought. It requires a pH of 6 to 7.5.

Varieties:

BPP 1(H 2 / 11): it is a selection from a cross between T. No. 1 x T. No. 273. BPP 2 (H 2/12): it is a selection from a cross between T. No. 1 x T. No. 273. BPP 3 (SCH 3/3): it is a survey collection from Simhachalam.
BPP 4 (EPM 9/8): it is a survey collection from Epurupalem.
BPP 5 (T.No.1): it is a clonal selection from Bapatla.
BPP 6 (T. No. 56): it is a clonal selection from Bapatla.
BPP 8: it is a selection from a cross between T. No. 1 x T. No. 39.
BPP 9 (H 3/28): it is a selection from a cross between T. No.56 x M 10/4.
In Maharastra: improved varieties are Vengurla 1,2,3,4 and 5. In Tamil nadu: improved varieties are Vridhachalam 1 and 2. In Karnataka: improved varieties are Ullal 1 and 2.
In Kerala: improved varieties are Anakkayam 1, BLA 39-4, K22 -1 .

Propagation:

It is propagated by seed and by vegetative means.

It is used to collect seed from high yielders. Elite mother tree should have the following characters

1. Compact canopy. 2. Dwarf trees with intensive branching 60% or more productive shoots per unit area. 3. Short flowering phase (2-3 weeks). 4. More than 20% bisexual flowers. 5. 5-8 fruits per panicle.6. Medium nuts with 5-6 grams average nut weight (120 to 130 nuts per kg) 7. Regular bearing habit.

Vegetative propagation:

Methods like air layering, patch budding, veneer grafting, side grafting, epicotyl grafting, soft wood grafting were found to be successful. However, soft wood grafting has become more suitable and commercial method of propagation of cashew nut.

Preparation of land:

Waterlogged, saline, alkaline soils must be avoided. Site should be cleared of all vegetation and ploughed 4 or 5 times in all directions and finally leveled.

Pits: 50 cm^3 pits at 8-10 meter spacing are dug during April – May. Pits are refilled with top soil mixed with 25 kg FYM.

Planting: Planting is to be done during July August. Plant 2-3 month old seedlings or one year old grafts. Provide water and support.

Irrigation: It is a hardy and drought tolerant plant. It requires irrigation during the initial 2 to 3 years.

Manuring:

Application of manures and fertilizers is essential for high yields.Nitrogenous fertilizers are given at bimonthly interval.

Year	June-July			September-October		
	N	P	K	N	P	K
First	25	25	25	25	25	25
Second	100	25	25	100	25	25
Third	150	40	60	150	40	60
Fourth	200	50	60	200	50	60
Fifth	250	60	60	250	60	60

After 5^{th} year 500 grams Nitrogen, 125 grams Phosphate and 125 grams Potash per tree per year in two equal splits. Manures and fertilizers are to be applied in trenches (10-15 cm deep) are dug at 100 – 150 cm from the base of the tree and 25 to 50 kg FYM depending on the age. Manuring is done when there is abundant moisture in the soil.

Intercultivation:

Basins should be kept weed free. Mulched with dry leaves or paddy husk during summer. Inter spaces ploughed twice in a year once at beginning and second at the end of rainy season. Alleys may be intercropped profitable.

Intercropping:

Groundnut, horse gram, cow pea, vegetable nurseries, paddy nurseries are taken as intercrops in Cashew nut orchards. Casurina is cultivated as intercrop in Andhra Pradesh and Orissa. Eucalyptus and Teak are grown as intercrops in Goa.

Training and pruning:

Side shoots must be removed upto a height of 150 cm from the ground level to get umbrella shaped tree.

Prune dead wood and criss cross branches between harvesting and blooming (June to December).

Cropping:

The crop comes to fruiting in 3-5 years and by 10th year it attains commercial bearing status. Commencement of flowering differs from west to east coast. Flowers during December to January on the west coast; January to February on the East coast.

Harvesting:

Harvesting commence from February on west; April on East coast. Fallen fruits are gathered. In Goa, fruits are plucked from the tree for preparation of a liquor called Feni. After gathering fruits, nuts are to be separated from apples. Nuts sun dried for 2 to 3 days, stored in gunny bags nuts should not be dried for more than four days, since they become brittle and break during processing and cause damage to the kernels.

Yield:

Yield depends on strain, soil, rainfall, sex ratio, fruit set and management.

Individual tree yields vary particularly in seedling progenies. Highest yields are obtained in Kerala. At 15 years age, 1600 kg per ha yield was reported at some places in Andhra Pradesh.

Processing:

Edible part is kernel. Extraction of this edible kernel from hard shell is called as 'Processing'. Processing is done manually in India. Mechanically in other countries.

There are 5000 units of Cashewnut processing in India. Quilon in Kerala has the largest number of processing units. In A.P, Vetapalem, Palasa and Mori are the important places of Cashewnut processing.

Steps in Cashewnut processing:

1. Roasting:

It is done for easy shelling to loosen kernel inside. Different methods of roasting are

i) Open pan method: perforated open pan is used for roasting the nuts. The nuts will catch fire after some time. Water is sprinkled and nuts are thrown to ground and covered with soil. In this method CNSL is not recoverable.

ii) Drum roasting method: Rotating metal drum is heated from below. Nuts catch fire within 3 to 5 minutes. A temperature of 100 to 120 ^{0}C is always

maintained inside the drum. Burning nuts are released at the other end and fire is put off by sprinkling water and ash. Rate of shelling and out turn of whole kernels are very high in this method. In this method also CNSL is not recoverable.

iii) Oil bath roasting method: nuts are held in wire trays. They are passed through at a bath of heated CNSL at 190 to 200 degrees Celsius. Nuts take a long time of 1 to 3 minutes for passing through the medium. Cells of shells get ruptured, they release CNSL. Nuts are cooled. 50% of the CNSL is recoverable. Uniform roasting is ensured it eliminates charring of kernels.

2. Shelling:

Breaking roasted nuts to extract kernel is called "shelling". Nuts are broken with wooden mallet. After cracking, the kernels are extracted with wire needle. Whole and clean kernels are to be extracted care fully. Shelling percentage vary from 15 – 30 percent.

3. Drying:

Extracted kernels are held in wire mesh trays, dried in hot chambers at 80 to 90^0C for 6 – 7 hours to loosen testa.

4. Peeling:

Thin reddish brown or pinkish outer skin of kernel is called testa. Removal of testa is known as peeling. Peeling is done by hand.

5.Grading:

Nuts are sorted out into different grades such as wholes, splits, brokens etc. Grading is based on the number of kernels per pound or kg is called count. Kernels are graded as wholes, splits, broken pieces. Grading is also done manually. There are 25 grades. 1. 210 count – Zambo wholes (best quality)
240 count 3. 280 count – American quality 4. 320 count – standard quality 5. splits 6. pieces 7. Baby pieces 8. Broken bits.

6. Sweating:

The dried kernels are brittle and are liable for breaking. The kernels are conditioned in humid chambes with 80% humidity for 5-6 hours. Humidity is maintained by air coolers. Kernels absorb moisture.

7.Packing:

Packing is done by vita pack method. After filling kernels tins are vaccumised and filled with CO_2 and sealed. Packed in 4 gallon tins (25 pounds).

LECTURE-17&18: Coffee – botanical name – family – origin – introduction – importance – botany – Arabica and robusta coffee - varieties – climate and soil – propagation – preparation of land – planting – provision of shade - training and pruning – manuring – irrigation – inter cropping – soil management – mulching – weed control – cropping – harvesting – yield – processing

Botanical name: Coffea arabica - Arabica coffee
C . canephora - Robusta coffee
Family : Rubiaceae
Origin : Ethiopia (South Africa)

A non-alcoholic beverage. Ethiopia is center of origin for C. arabica and that of C. canephore is less known. Spread through Arabs. Coffee cultivation confined to South States Karnataka (54%), Kerala 28% and Tamilnadu(16%). Now also in non-traditional areas like A.P., Orissa, NE States.In A.P. Chintapalli, Paderu, Machkund, Maredumilli, Sitampet, Ananthagiri hills, Araku, Srikakulam, East Godavari. Among total coffee area C.arabica occupies 60% and Robusta – C. canephora – 40%.More than 95% of coffee area in A.P., is occupied by Arabica

Botany :

Rubiaceae. Coffee genus consists of 70 species, out of which 4 species are important. C . arabica – famous for; its aroma ; C . canephora –popular for low cost of cultivation. C . liberica (Tree coffee) and C. excelsa are grown on limited scale for blending purpose

S.No	Character	C. arabica	C. canephora
1	Ploidy	Tetra 2n=44	Diploid 2n=22
2	Plant Status	Small tree, Shrub/Bush	Bigger tree
3	Root	Small, deep rooted	Large, Shallow
4	Branches	Persistent	Deciduous after harvest
5	Leaves	Dark green	Pale green
6	Flowering part	On new wood	On new and old
7	Regularity in bearing	Regular	Irregular
8	Flowers	Scaly, Small bracts, 4-5 inflorescence, at each node 1-4 flowers/inflorescence	Leafy,expanded bracts 5-6flowers/ inflorescence
9	Pollination	Self fertile, Self pollinated	Self sterile , Cross pollinated
10	Berries	Medium in size, 10-20/node	Small, 40-60/node
11	Fruit development	8-9 months	10-11 months
12	Caffeine content	1.47%	2.2%

Coffee plants are evergreen perennial shrubs. Two kinds of branches – i) Orthotropics: These are uprights and produce uprights and laterals ii) Plagiotropics: These are laterals and Produce laterals only.
Fruiting is on laterals only. On decapitation of orthotropics results secondaries (laterals), tertiaries and quarternaries are produced. Flowers appear in clusters, packed at nodes. Fruit is a drupe with two seeds inside, exocarp is often juicy envelops endocarp (parchment cell) within which seeds are enclosed.

Varieties:
1.Kent's coffee: Vigorous – red fruits
2.S – 298 : Hybrid released in 1938. Often pollinated vigorous with spreading habit. Fruits red/yellow with red streaks
3.S 795: 1946 – F2 hybrid of S 288 x Kent
4.S 1938: Resemble in 1960-61,F4 hyb of S 288 x Kent resemble kent in fruit and seed characters to a large extent
C C R I, Balahanur, Karnataka released leaf rust resistant Arabian coffee varieties
5.Selection 5: Hybrid devamachy x S 881 – vigorous and rust free
6.S – 6: Robusta x Kent's arabica
7.S – 8: (Hybrido – de – Timor) – spontaneous hybrid of robusta – arabica
8. S – 10 (Cotura crosses): catura x S 795
9.Cauvery catura x Hybrido - de – TimorR: Amenable for close planting, resistant to leaf rust

Robusta coffee varieties:
i) Selection 1R(S-274) : High yielder
ii) Selection 3R HybridR: C. congenesis x C. canephora compact growth – bushy with dropping branches suitable for high density planting.

Climate : Different species require different types of climate. Its growth mainly confined to Tropics – bet 28^0 N to 30^0 S latitudes. Coffee types are sensitive to frost
Water stress is essential to break the dormancy of flower buds. Cool winters are favorable for flower bud initiation. Rains with raising temperature after cool winter stimulates new vegetative growth, flowering and early fruit setting.

S.No.	Ctlimatic factors	Arabica	Robusta
1	Climate	Temperate climate in tropics	Warm humid conditions
2	Elevation	900 – 1500 m	500 – 1000 m
3	Annual R F	1600 – 3000 mm (over 8-9)	1000 –2000 m
4	Temp	15 –35 ^{0}C	20 –30^{0}C
5	RH	70 –80 %	80 –90%
6	Shade	Medium to light shade	Uniform thin shade

		depending on elevation and aspect	
7	Aspect	N, E, NE	Flat to gentle slopes
8	Blossom rain	Mar – Apr	Feb – Mar
9	Backing rain	Apr – May	Apr – Mar

Being slender, the branches may break due to strong winds. Winds during fruiting may affect the set and development. So protected sites like hill slopes are best. Well distributed R.F with dry months from Dec – Mar and summer showers are important for flowering.

Soil:

Can be grown on hill slops and on lands with undulating topography. Deep, friable, porous in nature and good aeration rich in organic matter, with good water holding capacity, each in potassium and slightly acidic (6.0 – 6.5). In India, coffee is cultivated in red and lateritic soils.

Propagation :

Coffee is propagated both by seed and negatively (cuttings). Good shaped, high and regular yielding, excellent quality beans, disease resistant, are marked as mother plants. Healthy fully mature, ripe fruits are collected. Hand pulped with ash and extracted seeds dried in shade. Seeds sown within two months of gathering or seeds stored with dry powdered charcoal for 10 months without loss in viability. Select light to medium loam, humus rich, nematode free pest free, gentle slop, partially sheltered site.

Raised beds(15 cm) one meter width and convenient length are prepared. Four baskets of FYM/ Compost, 2Kg line, 500 g rock phosphate are incorporated into a bed of 1 m x 6 m size. Seed treated with agrosan, sown in Dec-Jan months flat side facing the soil. Seeds sown 2.5 cm apart in the rows, which are spaced at 15 – 20 cm.

Covered with thin layer of fine soil bed is covered with 5 cm paddy straw to ensure even temperature and conserve moisture. Beds are watered daily, protected by direct sun light by erecting an overhead pandal. Germination commences in four weeks turned and will be completed within another 5 to 6 weeks. When the seedlings are 5 – 8 cm tall, shifted either o secondary nursery beds or to poly bags of 150 gauge during Feb – March. Secondary nursery beds are prepared in the same way as in the case of seed beds. Seedlings are transplanted at a spacing of 15 –20 cm within the rows spaced at 30 cm apart. Regular watering and after case of the seedlings should follow Overhead shade gradually thinned – removed before the onset of monsoon.

Seedlings maintained in the secondary nursery beds for 16 – 18 months Seedlings manured once in two months with Urea solution(@ 20 g in 4.5 litres water)

Cuttings : Obtained from bushes of outstanding performance and free from pests and diseases. Single node, 3 – 6 m old, semihard wood (greenwood)

cuttings 1.0 cm long with two basal leaves are prepared. To enhance rooting, the bases dipped in 5000 ppm (BA at planting.).

Cuttings are planted in poly bags filled with forest soil, sand and FYM during rainy season (June, August). Poly bags with cuttings are arranged in a trench (2m width, 50 cm depth and of conv. length) covered with thick polythene sheet over a frame work of bamboos or aluminum framed. Cuttings will root in about 3 months after planting and hardened under shade for 2 months. Propagation by cuttings is not an established practice in India.

Establishment of coffee orchard:

Preparation of land: Selective retention of desired sp.of shade trees is essential. Land is prepared a season in advance of planting. Paths – roads – divide into blocks – terracing in sloppy lands.

Spacing : Arabian coffee – 2 to 2.5 m, robusta 2.5 to 4 m in square system Digging and Filling: 45 to 60 cm3 pits prepared, refilled with top soil + forest soil Planting : June to September, Disease free vigorous seedlings / Rooted cutting Shade: In India – require partial shade where sunlight is on tense.To conserve moisture, to keep soil temperature at optimum level. At high elevations shade may not be required.

Shade comprises two canopies lower (temporary) and upper (permanent). Temporary - Lower canopy - Dadep - Erythrina Lithosperma planted along with coffee at 4 m apart on either way next to dadap - silver oak (Grevilla robusta)

Permanent : S.India - Albezzia lebbek, Artocarus chtegrifolia Dalbergia latifolia

Ficus formerate F. infectoria & F. retusa. Planted at 12 – 14 apart. Large no.of permanent shade trees are initially planted and thinned out as required. These trees have to be regulated in such a way that their conoty is 10 - 14 m above coffee planted. Shade trees should be regularly pruned and lopped to provide required filter shade to coffee.

Training and Pruning:

1. Single stem system: When the plant reach 75 cm in arabica : 110 – 120 cm in robusta it is topped to restrict the vertical grower.Facilitate lateral spreading and increase bearing wood. Improve ground coverage, root system is sheltered.Ideal for low RF areas and followed in India.

2.Multiple stem system: Common in Kenya – Erect branches grow from the base of the main stem in restricted number (4 – 6). Allowed to grow either topped or un topped at 2 m height. System allows more efficient spraying and harvesting and greater ease in pruning.

Pruning is done immediately after harvest to replace worn out branches Centering : Removal of veg. growth up to 15 cm radius and up to the first node Desuckering : Removal of orthotropic branches

Handling : Removal of small axcillary sprouts, otherwise grow towards inner side and cause shade.

Nipping : Growing tip of primary branches is removed to encourage secondaries and tertiaries.

Manuring:

Produce fruits and fresh wood, simultaneously.

Leaching in heavy rainfall areas.Time of flowering, fruit set, development and maturation.

Time of often age of pt.	Preblossom March N P K	Post blossom May N P K	Midmonsoon August N P K	Postmonsoon October N P K	TOTAL N P K
1 yap	15 10	15 10 15	--	15 10 15	45 30 45
2 & 3 yap	15	20 15 20	--	20 15 20	60 45 60
4	20 15	20 20 20	20 : 0 : 0	30 20 30	80 60 80
5 & above	20				
< 1 + /ha	30 20	40 30 40	40 30 40	40 30 40	160 120 160
> 1 +/ha	30	40 30 40	40 30 40	40 30 40	160 120 160
		ROBUSTA			
< 1+/ha	40 30	--			
> 1+/ha	40	40 30 40	--	40 30 40	80 60 80
	40 30		--	40 30 40	120 90 120
	40				

Manuring andFertilizers are applied below drip line in a band bet 30 & 45 cm.Mulching, incorporating bulky org.manures, green manure, cover crop and prunings of shade trees – to add humus.

Irrigation:

Raised as rain fed crop. Sprinkler irrigation , against failure of backing showers. Used young plantation for better establishment of coffee and shade trees.

Inter cropping :

Can be cultivated with many other crops annuals and perennials.In coconut gardens – robusta coffee – at 2.5 m x 2.5 m Arabica. Inter cropped with mandarin oranges in Karnataka.Tea is also inter cropped with coffee.

Soil management :

I)Scuffling: Soil stirring is done towards the beginning of dry period for controlling weeds and conserving soil moisture.

II) Mulching : Mulched to maintain optimum soil temperature, conserve soil moisture, Control erosion – adds fertility.

III)Weed control: In young plantions; 3 – 4 times weeding/year In old orchards – trice or thrice in an year.1. During monsoon 2. Towards end of monsoon 3. During post monsoon . Grammoxone @ 1.25 lt / 450 lts of water / ha for effective weed control.

Cropping :

Fruit in 3 rd year of ptg. Productive life is 30 – 50 years dep.upon climate and management.

Harvesting :

Arabica comes to harvesting earlier in the season (Nov. – Dec.) since they take 8 – 9 m for fruit development; Robusta – 10-11 m (Jan.- Feb.).Harvested by hand ripe berries are hand picked. Pick as and when they ripe for better quality, several pickings are done 4 pickings

1. Fly picking : First picking in the season. Selective picking of ripe berries during other continued till February.

2. Main picking: Well formed and fully ripened berries are harvested 4 to 6 times at 10 – 15 day interval from Dec. Bulk yields are obtained during this period.

3. Stripping : Final harvest. Picking berries left on the pt irrespective of referring stage.

4. Cleanings : Collection of dropped berries.

Yield:

Vary according to climate, variety, cultural condition, management of plantation & to a large extent on weather conditions at and after flowering. Arabica – 480 Kgs dry berries/ha ; Robusta – 490 Kg/ha.

Processing : commercial coffee – beans of coffee with pulp removed (parchment)

Pulp must for removed. Processed in two ways : 1. Wet processing(Parchment coffee) 2. Dry processing (Cherry coffee)

A.Wet processing: For "Arabica" coffee yields superior quality product .

i) Pulping: Sweet mucilaginous pulp + skin, removed with the help of pulpers on the same day of harvesting.

ii) Demucilaging : Remove mucilage, otherwise, leads to moulding and musty small of the beans.by two processes

a) Fermentation : Commonly used mucilage breaks down during fermentation. Time required varies with variety and degree of ripeness. Arabica – 36 hrs; Robusta – 72 hrs when correctly fermented – mucilage do not stick to land.

b) Alkali treatment. : After draining excess water, pulped beans treated with 10% solution of caustic soda (sodium hydroxide) mass is stirred thoroughly and trampled & washed Arabica – l lr. Robusta – 2 hrs for alkali treatment.

III. Washing : Demucilaged beans soaked in water for 24 hours and then washed thoroughly in running water, 3 to 4 times until the stickiness completely disappears.

IV. Drying : Now in parchment stage. It is dried in sun/ air driers washed beans are spread on clean tiled or concrete drying floor to 7 – 10 cm thickness. Beans raked and stirred frequently. Parchment should be heaped up and covered in the evening until next morning sun drying takes 7 – 10 days depending on weather.

V. Storage – stored in new, clean gunnies.

B. Dry processing (Cherry coffee) : For Robusta coffee;

Harvested berries are either sun dried or in air driers – usually sun drying is adopted, Sun dried for 12 – 15 days on drying floors, with frequency stirring and turning of beans for uniform drying. End point – Rattling sound of berries Sun dried coffee possess better flavor than that dried artificially. Dried coffee stores well; dried pulp forms hard protective cover on beans. Dried pulp is removed by pounding in a mortar or by hulling (on large scale). Does not require any elaborate equipment and is simpler & cheaper dry season should coincide the time of ripening.

LECTURE-19&20: Coconut – botanical name – family – origin – economic part – importance – botany – varieties – tall, dwarf and hybrids – climate – soil - planting – manuring – irrigation – intercultivation – harvesting and yield

Botanical name:	Cocos nucifera
Family	: Palmae
Origin	: Indo-malayan Region (South East Asia)
Plant part	: Tender stems with flower panicles

Uses and Importance:

Most useful palm of the world. Provides food, drink, oil, fibre, shell and fuel, thatch, beverage, timber for domestic fuel. Hence called as 'kalpa vriksha'

It is one of the cooking media in our country as well as in South East Asian countries.

It produces 60% of edible oil, consisting of saturated and unsaturated fatty acids.

The oil is used in the industry for the manufacture of detergents, cosmetics and other related products.

The hardened white endosperm which is called as white meat is used for the manufacture of different products like copra, copra flour and it is being used extensively in the confectionery and food industry.

The liquid endosperm which is a source of minerals and vitamins forms a delightful nourishing drink.

The hard endocarp is called as shell and it is used as a fuel and also for the extraction of tannins.

The coconut leaves are used for covering the thatched houses.

From the midrib of the leaf fibre is extracted and is used for making ropes.

The thick mesocarp of coconut is used for making attractive, decorative products and the dust being used for making coco beat which is a media for growing hi tech floricultural plants and for hardening tissue culture saplings.

In the world it is extensively grown in South East Asian countries where India, Indonesia and Philippines occupies 1,2 and 3 positions.

In India, it is extensively grown throughout the country but longest areas are observed in Kerala with 48.28% of production followed by Tamil nadu of 12.8% of area and 23.63 per cent production and Karnataka 16.2% in area 14.68% in production and A.P. with 3.94% in area and 2.82% of production. The rest of states share about 9.82% in area and production.

In A.P., the coconut growing areas are divided into two groups.

1. Conventional areas: konaseema of East Godavari and West Godavari, Krishna and Guntur
2. Non conventional areas: Nizamabad, Warangal and Khammam district.
3. Uddanam: Vizag, Vizianagaram, Srikakulam (north coastal districts). Maximum production of this crop is from conventional areas and uddanam region.

Production phase continues up to 80 years.

Coconut is cultivated in more than 80 countries in the world. India ranks 1st in production area and 3rd in area after Philippines and Indonesia.
In India, it is cultivated in 1.51 m ha with 11.3 thousand million nuts. 90% of its cultivation is confined to South states, viz., Kerala, Karnataka, Tamilnadu and Andhra Pradesh. Kerala alone accounts for 60% of the total area under Coconut. Cultivation is spread over the entire coastal belt of the country. Crop is also grown in Goa, Orissa, Maharashtra, Assam, West Bengal, Gujarat and Union territories. In A.P., Coconut cultivation is mostly confined to coastal districts. Economic importance:

Most important source of vegetable oil in the world. Kernel has 65% oil.(oil palm 46%). Copra and coconut oil are the traditional products for oils and fats. Provide raw material for a number of industries. Provide employment to more than 10 million people. Coconut based industries include coir manufacture, copra processing, oil milling and distillery. Export of coir and coir goods alone earn Rs.
260 million foreign exchange.

Botany:

In the genus Cocos, the C. nucifera is the only species available. The palm is called as caudex and it is tall, unbranched palm growing to 15-30 meters. Stout trunk raising from swollen base. It has fibrous roots. Stem terminates into a radiating crown of leaves. Leaves are born at crown region and they are called as fronds. The leaves are pinnately compound with swollen petiole. The leaf petiole scars are present on the surface of the stem which are inconspicuous at the base and prominent above 1 m height. Leaves are long, large, pinnately compound. Monoecious, one inflorescence in one axil, every month. Inflorescence is called as Spadix and it is enclosed in a spathe consisting of two boat shaped sheaths. The inflorescence originates in the axils of leaf and opens at the time of anthesis. When fully grown, spathe splits longitudinally release inflorescence. The inflorescence possess main rachis and secondary rachices. Female flowers (buttons) appear at the base. They are called as buttons. The number of female flowers per inflorescence varies from 10-15. Female flower has tricorpic ovary. Male flowers are located at distal ends which come to maturity early that the female flowers. Male flower has 6 stamens;
Male flowers open earlier, so necessitate cross pollination. Female flower production is high during March to May and low from September to January. Fruit is a large one seeded drupe, round or ovoid in shape. Fruit has Epocarp (green coloured thin layer), Mesocarp (the cushiony thick layer), Endocarp (the hard shell), testa, meat or kernel. The water is known as liquid endo sperm. The white coloured soft meat is known as hardened endosperm or white meat. Embryo is present at the tip of the meat.

Varieties:

Varieties are classified into two groups i.e. 1. Talls and 2. Dwarfs.

Tall varieties are extensively cultivated. Talls and dwarfs are crossed to produce hybrid varieties.

Tall varieties:

They are hardy, reach a height of 30 meters and live up to 80 years(long life span). Stout trunk, bole come to bearing late (6-8 years.) Fully developed leaves measure 6 m. Regular bearers and are allogamous (cross pollinated) Bearing starts late after 7 years. Good yield (commercial yield) starts from 10th year and extends up to 70 years. Nuts are suitable for manufacture of copra and extraction of oil.

Ex: East Coast Tall, West Coast Tall, Laccadevi ordinary, Laccadivi micro and Andaman ordinary.

Yield is more i.e. 70-100 nuts, 165-175 grams copra per nut and 70% oil.

95% of the area is under East coast tall.

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%

Dwarf varieties:

Short statured, early to bear (3 – 3 ½ years after planting). Palms are short lived 40-50 years. Trunks are without bole. Fully developed leaf measure 4 meters. They exhibit alternate bearing.

They are autogamous (self pollinated).They bear early.

Commercial yield starts from 5th year and extends up to 30 years. Nuts small – copra soft and leathery with low oil. Quality of copra is inferior to tall varieties hence they are extensively used for water. Dwarfs grown for tender nuts and ornamental palms and hybrids. Exhibit three nut colours – green, yellow and orange.

Chowghat orange dwarf (COD), CGD, Malayan Green Dwarf (MGD), MYD, MOD, Ganga Bondam.

They are medium yielders

Regular planting with dwarfs not taken up, due to they require better growth conditions and better care, low yields, poor quality of copra.

Hybrid palms:

To achieve precocity, more female flowers, large nuts, high copra and oil, hybridization between talls and dwarfs was carried out. Talls and dwarfs of commercially grown cultivars can be crossed to exploit hybrid vigour. They can also be crossed reciprocally. Earliness to bear, yield and quality of copra are the characters of some of the promising crosses made in Andhra Pradesh and from Kerala Agriculture University for commercial cultivation.

The following cross combinations were tried.

Talls x dwarfs;

Dwarfs x tall.

D x T hybrids were found to perform better, though late in bearing.

Important hybrids: T X D hybrids

	West coast tall	x	Chowghat Orange Dwarf.
Chandra Laksha	Laccadivi ordinary	x	COD
Laksha Ganga	Laccadivi ordinary	x	Ganga bondam
VHC – 1	East coast tall	x	Malayan Green Dwarf
VHC – 1	East coast tall	x	Malayan Yellow Dwarf
Godavari ganga.	East coast tall	x	Ganga bondam
Kerala ganga	West coast tall	x	Ganga bondam
Anantha Ganga	Andaman ordinary	x	Ganga bondam

Godavari Ganga was released by Agricultural Research Institute, Ambajipet, East Godavari district.

Double Century: It is another variety released by the above research station. It is the clonal progeny selection. It is named so because it bears not less that 200 nuts per palm per year and it is a 200th variety of ANGRAU.

Spiccata: it is popular as it produces unbranched inflorescence.

D x T: Chowghat orange dwarf x west coast tall = Chandra sankara

Climate:

A tropical plant. Grow between 260 N and S latitudes. Does not tolerate extremes of temperature. Generally its cultivation is below 600 m

elevation; Can be cultivated up to 1000 m elevation. Requires humid warm climate with an average annual temperature of 27^0 C with a diurnal variation not exceeding 7^0 C. When temperature is less than 22^0C, palms does not flourish. Temperatures below 15^0 C, impair fruiting. Require 2000 sunshine hours per year with 120 hours per month. Does not grow under shade. If grown under shade palm become lean and lanky. Palms tolerate wide range in intensity and distribution of rainfall. Annual rainfall of 2000 mm with even distribution is best for proper growth. Irrigation is required in the areas of uneven rainfall distribution. Soil moisture deficit during summer hampers nut production greatly.

Soil:

Adaptable to wide range of soil conditions from light sandy to heavy clays. In heavy rainfall areas – well drained types of soil. In poor rainfall areas – deep fine soils are essential. Clayey, black cotton soils, subject to water logging; shrink and crack during dry periods are not suitable. Sandy soils support good crop, when there are assured sources of ground water. Laterite soils – should be deep up to 1 m or below without a rock or hard pan. Alluvial, red sandy and silty loams are also suitable provided they are well drained.
Alkaline, saline soils are not suitable. Ideal pH is 5.2 to 7.0

Planting material: Sexually through seeds.
Selection of mother palm:
1. Middle aged (25-40 years); spherical or semi-spherical crown and 30-40 opened leaves, an inflorescence in each axil, with at least 2 female flowers on each spikelet and yield high (more 120 nuts per palm per year). Regular yielding, free from pests and diseases.
2. Length of petiole and bunch stalk should be short and stout.
3. Palms growing close to houses cattle sheds, compost heaps etc may be avoided as it is difficult to identify inherently good trees.
4. Nuts should be medium sized; nearly round or spherical. It should be typical of the variety; 12 months; from January to May. Stored for 30-45 days under shade over a layer of about 7-8 cm.
5. The bunches should have a preponderance of heavy nuts.
6. Trees producing barren nuts should be discarded.
7. Open sites are selected; nursery should be raised in sandy soil. Should have adequate drainage and irrigation facility.

Collection of seed nuts:
1. The time of harvest of seed nuts vary in different regions
2. West coast seed nuts are harvested during February to March.
3. Seed nuts should be 11-12 months old.
4. Seed nuts should be cut and lowered by ropes to avoid any damage.
5. Seed nuts should be cut and are arranged by their stalk end u on the floor of a shed over a layer of about 7.5 cm dry sand and completely covered with it till the planting time.

6. For multiplication of coconut selection of mother palm, seed nut and seedling plays an important role for getting quality plant material.

Coconut being cross pollinated plant mother plant is selected with utmost care. Nursery should be near a water source. Field should be worked to fine tilth. Field is laid out into raised, long and narrow beds to accommodate 4-5 rows at 30 x 30 cm. Seeds planted in the nursery at the beginning of monsoon in shallow trenches 20-25 cm deep) at 30 x 30 cm. Planted either horizontally or vertically with husk visible. Horizontal planting is preferable, seedlings will be robust. Suffer less damage, exhibit higher germination and vigorous growth. Irrigated adequately after planting. Nursery needs regular watering, weeding and plant protection for getting early and maximum germination. Seed nuts treated with 0.2%. BHC is applied against termites. Nuts germinate within 10-12 weeks in A.P. In 5 months maximum seed nuts would germinate. Seedlings distributed at 9-12 months, whereas in A.P. and Karnataka 6-8 month old

seedlings are lifted and planted in secondary nursery at 90 cm to 1 meter either way. Where the planting is done in ponds submerged in water 3 year old saplings are preferred.

Selection of seedlings:
Seedlings selected at 9-10 months.

1. Early germinated,
2. Healthy and vigorously growing seedlings.
3. With good girth (10-12 cm) at collar region and
4. At least 6-8 opened leaves
5. showing the indication of early splitting are selected.

Selected seedlings are lifted carefully.

Preparation of land: Land is cleared. Ploughed deeply and repeatedly from all directions. On slopes, contour bunding or bench terracing depending on the degree of slope. Where water table is high, raised mounds are formed. On plains, leveling is done.

Planting:

Planting is done at the beginning of South west monsoon. If irrigation is available, planting can be done even in May. In heavy rainfall areas, plant at the end of rains. Planting can be taken up in the months of June- July and again during September and October. After planting the plants are tied to a stake and irrigated properly till they are established.

Spacing:

A spacing of 7.5 to 9.0 m in square system. Spacing varies depending on planting system, type of culture, soil type and variety etc. For tall varieties triangular system of lay out with 7 to 7.5 m. For dwarf varieties square system with 6 m spacing is adopted. In monoculture – closure spacing and in case of intercropping wider spacing is given.

Digging and filling pits:

Pits of 1 m cube are dug up during summer and left for weathering. Few weeks before planting pits are filled up to 50 cm depth, with top soil mixed with river sand, wood ash, bone meal, MOP and 50 grams BHC 10 % dust. In sandy soils, two layers of Coconut husk spread at the pit bottom, compost or FYM should not be added to the pit. After filling pits are watered and allowed to settle.

Transplanting:

Seedlings are transplanted in the pit by scooping out a small hole in the centre of the pit. Seedlings should be staked and watered.

Care of young palms:

The care of young palms during the initial 3-4 years will influence the growth of young palms; bearing age; productivity. Seedlings fenced against cattle, shaded against sun, regularly irrigated.

Pits/ basins weeded periodically, mulched with coir dust, coir / paddy husk. Protected from insect pests like termites, leaf eating caterpillars, rhinoceros beetle. Gap filling should be completed within first year. Regular manuring from first year of planting.

Young palms require more Nitrogen and Phosphorous compared to adults.

	Year	Rainfed talls	irrigated talls and hybrids
1.	3 months after planting	1/4th adult dose	¼ th adult dose
2.	2 nd year	3/8th adult dose	½ adult dose
3.	3rd year	½ adult dose	3/4th adult dose
4.	4th year	¾ th adult dose	full adult dose
5.	5th and above	full adult dose	full adult dose

Green leaves, compost, FYM @ 15-20 kg per palm per year need to be applied from second year.

Applied twice in a year for rainfed crop (May-June; October to November) four times a year for irrigated crop (April – May, August – September, December and February). Manures and Fertilisers are applied to young palms at a distance of 25 – 50 cm from the trunk and forked in, basin size is increased as the palm grows up to 2 m at flowering.

Irrigation and moisture conservation:

Palm needs large quantities of water for satisfactory performance. Due to irrigation, production of female flowers and setting percentage increase considerably. Irrigation is more essential in light soils and areas of low rainfall and long spells. Common method is Basin and flood irrigation; when water is scarce drip irrigation is to be provided. In rainfed coconuts mulching of basins is required. Trenches are dug all along the row to a depth of 90 cm and 60 cm width. They are filled with Coconut husk layer after layer mixing with dug out earth. Coconut dust is placed around the plant absorbs the moisture and

maintain cool atmosphere around the root zone. Coconut husk and coir dust (as sponge) absorb moisture 6 & 8 times by weight and release slowly during dry periods. Decompose slowly and will lost for 5 to 6 years and 8 – 10 years respectively and add potash to the soil. Husks/ dusts can be buried in layers alternating with soil in pits or trench dug up in between the rows of trees at a depth of 0.5 to 1.0 m and 2.0 m away from the palms.

Manuring:

Remove large quantities of nutrients from the soil. Should be replenished promptly and regularly.

Year	FYM	N	P	K
1st & 2nd	25 kg	150g	100g	150 g
3rd year	50	300	200	400
4th and 5th	75kg	450	300	650
6th year onwards	100kg	600	400	800

In addition to the above 500 grams Mg SO4 is to be applied along with the adult dose. June- July and November – December months is the time for fertilizer application in irrigated conditions. July-August is the time for rainfed conditions. Organic manures are applied during monsoon. In light soils manures and fertilizers are applied 2 meters away from trunk and forked in. In other soils trench is dug 2 m away from trunk and fertilizers are applied.

Intercultivation:

Includes ploughing, digging or raking the soil. Intercultivation loosens the soil, for better aeration. Prevents matting of roots and controls weeds. Land is ploughed twice in winter and twice rainy seasons.

Cover cropping:

Cover crops – check soil erosion. Protect soil from exposure to sun and rain. Control weeds.

Increase organic matter and add nitrogen. Legumes like Mimosa invisa, Stylosanthus gracilis and Calapogonium mucanoides.

Intercropping:

Coconuts are widely spaced. Pre-bearing age is 6 – 8 years. Take intercropping up to flowering and after 25 years. Vegetables like pineapple, banana, elephant foot yam, groundnut, turmeric, ginger, potato tapioca and sweet potato. Provide irrigation separately for intercrops.

Mixed cropping:

Growing long duration crops in alleys of a perennial. Crop is mixed cropping. Shade loving or shade tolerant crops are mixed cropped. Ex: Cacao, clove, nutmeg, Cinnamon, Black pepper. Adequately and separately manured.

Harvesting:

Talls start flowering 5-7 years after planting. Dwarfs flower 3rd year. Full bearing attained after 2-3 years. Once enters bearing, continuously produce

flowering. 12 bunches are expected year. They take 11-13 months from flowering to maturity. Hallow sound on tapping, brown colouration of husk are the maturity indices. However coconuts are harvested at different ages for different purposes are as follows…

Tender nuts	6-7 months old.
Green husk	10-11 months old.
Copra and oil	11-12 months old.
Seed	12 m

Monthly harvests are made for tender nuts. For copra and oil matured nuts are harvested at 45 days interval during summer and 60 days interval during rainy season. 8 – 10 harvests are made per year. For seed only one harvest is taken per year.

Yield:

Tall variety 60-80 nuts under rainfed conditions. 80-100 nuts under irrigated conditions.

LECTURE-21: Oil palm - botanical name – family – origin – economic part – importance - botany – varieties – climate – soil – propagation and planting – irrigation - intercultivation – harvesting – yield – processing

Botanical name:	Elaysis guineanssis
Family	: Palmae
Origin	: West Africa
Plant part	: Nut and mesocarp

Commonly also known as African oil palm, Red oil palm
Importance: 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

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 Eleidobius 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 @ 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

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.

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

LECTURE-22 & 23: Medicinal plants – scope and importance – cultivation of medicinal plants in India. Diascorea and rauvolfia - botanical name – family – origin – economic part – importance – botany and varieties – propagation – climate – soil – preparation of land – planting – irrigation – intercultivation – manuring – harvesting – yield

Medicinal plants are those plants rich in secondary metabolites and are potential sources of drugs. These secondary metabolites include alkaloids, glycosides, coumarins, flavonoids, steroids etc.

These plants form the main base for the manufacture of drugs of Indian systems of medicine (ayurveda, Unani, Siddha) and Homeopathy. These plants are found in various parts of the country in different environmental and climatic conditions. Plants which grow wild in forest regions, classified as minor forest produce, supply a substantial amount of raw material required for the indigenous drug industry.

Importance and scope for cultivation of medicinal plants in India.

1. India is one of the few countries where almost all the known medicinal plants can be cultivated in some part of the country of the other. Among the various plants in great demand in the country and abroad are Opium poppy, tropane alkaloid bearing plants, sapogenin bearing yams, senna, psyllium husk and seeds, cinchona and ipecac.
2. The ancient Indian System of Medicine (ISM) is predominantly a plant-based material medica making use of most of our native plants. It caters to almost the entire rural population of our country mainly because of the scarcity of modern allopathic health care in our villages
3.ISM offers most appropriate or first line therapy against many diseases like jaundice, bronchial asthma, rheumatoid arthiritis, diabetes etc, for which allopathic medicines have as yet no cure. It is well known that most allopathic medicines have as yet no cure. It is well known that most allopathic medicines produce many morbid side-effects. It is for this reason that more and more people in the western societies are showing increasing interest and preference for organic drugs and their preparations.
4. India has about 2,000 species of medicinal plants and a vast geographical area with high production potential and varied agro-climatic conditions. Most of these plants can subsist under stress conditions and are thus suited even for rainfed agriculture. Cultivation of medicinal plants offers considerable scope for rural employment and export for foreign-ex-change earnings.
5. India is already a major exporter of medicinal plants. It is estimated that rupees
86 crores worth of raw materials and drugs from medicinal plants are exported from India. It holds monopoly in the production and export of psyllium and senna and is second largest exporter of Opium latex.
6. Many of the medicinal plants required by the trade are gathered mainly from the wild growth thus depleting the vegetation of its valuable medicinal plant

wealth (eg: Rauvolfia, Dioscorea). On account of this practice, many species of medicinal plants in our country have become extinct or endangered. This should be prevented and herbal gardens and gene-banks covering important medicinal plants should be established to conserve them.

DIOSCOREA - (Medicinal Yam)

Botanical name:	Dioscorea floribunda
Family	: Dioscoreaceae
Origin	: Central America (Mexico)
Plant part	: Rhizomes (tubers)

Also known as medicinal yam. Although yam tubers contain a variety of chemical substances including carbohydratess, proteins, alkaloids and tannins, the most important constituents of these yams are sapogenins.The most important sapogenins found in the various species of Dioscorea are diosgenin, yamogenin, botogenin and kryptogenin. Out of these diosgenin is the most important sapogenin used as a starting material for synthesis of a number of steroidal drugs.The steroidal drugs (6% of total pharma industry) derived drugs derived from diosgenin include corticosteroids, sex hormones, anabolic steroids and oral contraceptives.

The growing need for survival drugs and the high cost of obtaining them from animal sources led to wide spread search for plant sources which ultimately led to the discovery or genus Dioscorea as the most promising one.
Some of the species like D. alata and D. esculanta have been cultivated for a long time for their edible tubers.About 15 species are known to contain steroidal constituents, chiefly diosgenin.
Varieties: related to D. floribunda

IIHR – FB (c) -1 and Arka upkar released from IIHR, Bengalore
Pusa- 1 by IARI, New Delhi

Soils:

Dioscorea plants can be grown in a wide variety of soils. In sandy soils, they require heavy irrigation and fertilization. Harvesting of tubers is also easier in light sandy soils. Heavy soils are not good, in general as they restrict tuber growth and make harvesting more difficult. Best yields are obtained in medium loam deep soils, which are rich in organic matter. The structure of the soil influences the morphology of the tuber. Light soils allow the tubers to grow thinner, longer and deeper than heavy soils. Dioscorea tolerates a wide range of soil pH, but too acidic and highly alkaline soils should be avoided.

Climate:

They can be grown in tropical, sub tropical and temperate climates in India.

1) D. floribunda, D. Compesitae - Grown in tropical conditions

2) D. deltoid -Temperate – Kashmir & Himachal Pradesh

Propagation:

Dioscorea floribunda can be propagated either by head tuber pieces or single node cuttings. Commercial plantings could best be established by tuber pieces only. But the availability of sufficient tubers for large scale planting is a problem. One the other hand seed progeny is variable and it may take longer time to attain tuber yields compared with plants raised from tuber pieces.

I. Seed propagation:

Dioscoea floribunda is a dioecious plant i.e., male and female flowers are borne on separate plants. Female plants will not set seed unless they are planted very close to the male plants for effective pollination.

Under Bangalore conditions, flowering starts from August and seeds mature from December to February.The seed pods should be collected when they turn brown but before they dehisce and are dried in shade.

Method of raising seedlings:

For raising a commercial crop from seed, seed should be sown in polythene bags (8x 12 cm) in the month of February. A mixture of equal parts of sand, soil and FYM is found to be the best medium.A thin layer of vermiculite should be used on the top.Two seeds are sown in each bag at a depth of not more than 1.25 cm. The bags should be watered and kept moist. Germination will be completed in about 4 weeks and the seedlings are ready for planting in 3-4 months. Nursery should be provided with shade. The seedling should be staked with thin sticks.

II.Propagation from tuber pieces:

Size of tuber pieces:

The preferred method for multiplication of D. floribunda for commercial planting is from tuber pieces.Anatomically the tuber is a swollen hypocotyle. Therefore, except for the crown where there is a growing bud and the rest of the tuber does not have any preformed buds.The tubers can be divided into three distinct parts viz., crowns (stem end) median (middle) and distal (tip end).The crown has a preformed bud but the other two parts do not have any preformed buds. Under specific conditions of storage they also develop adventitious buds. All the three pieces can be used for propagation. Crown sprouts new shoots with in 30 days of the planting since they have preformed buds. However medians and tips may take up to 100 days to sprout.For commercial planting crowns are preferred as they sprout earlier and yield higher, in comparision with medians and tips.However, if there is a shortage of material, medians and tip portions, can also be used for planting.

Before planting, the tubers are cut into pieces weighing about 50-70g each. With smaller pieces the growth and yields are poor. The plants raised from bigger tuber pieces (80-100g) significantly out yield the plants raised from smaller pieces, but the increased yields are not proportional to their size.

Tuber treatment:

The tubers are susceptible to a number of soil borne diseases so they are treated with proper fungicides soon after harvesting.The tubers may be

dipped for 5 minutes in 300 ppm solution of Benlate and then dusted with 0.3% Benlate talcum powder before planting or store in moist sand beds for checking the soil borne diseases effectively.

Storage of tuber pieces:

Direct planting of tuber pieces in the field immediately after harvest is not recommended as it involves expenditure on irrigation, weeding etc in the field for about 3 or 4 months as they take 30 to 100 days for sprouting.

It is best that part of the time taken by tuber pieces for sprouting can be spent in moist sand beds (300 x 90 cm).The tuber pieces are stored in a moist well aerated rooting medium (sand beds) until shoot growth commences. The sand beds consist of alternate layers of sand and tubers (4-5) and should be watered regularly and should be under shade. After 30 days the sand may be removed and the crowns are taken out and planted in the field.The medians and tips left over are again covered with sand and watered regularly.After 90-100 days, these pieces are also removed and planted in the main field.

Season of planting:

Under Bangalore conditions the tuber pieces are planted from March to April.

III. Single node cuttings:

D. floribunda can be easily propagated single node cuttings in mist chamber (intermittent). The cuttings consist of a single leaf with petiole and about 1 cm of the stem. The cuttings should be taken in the early part of the year from non-flowering plants.The stem of the leaf cuttings should be dipped in 10 ppm solution 2,4-D or quick dipped in 5000 ppm of IBA solution.The cuttings are planted in the mist chamber in sand beds.The callus is formed in about 4 weeks time.The shoot and the roots develop subsequently.8-10 weeks old plants are transferred to plastic bags, with a planting mixture of equal amounts of sand, soil and FYM. After about 6 months of growth in the nursery they are planted in the field. This method is not commercially used as it is very slow, time consuming and costly.

Planting:

Sprout tubers planted at 5cm depth, 30-45 cm apart with a spacing of 60 x 30-45 cm

Stacking:

Dioscorea plants are climbers, hence need support. This provides exposure of maximum amount of surface for photosynthesis. Provision of proper support gives better growth and also decreases losses due to diseases and pests, because of better aeration. Trellies system was found to be suitable for growing dioscorea yams. It consists of high stone pillars and spaced at 10 cm apart in the field. Galvanised iron wires are used on the four ends of the field and they are interconnected with wires. Each plant is tied to the over head wires.

Manuring:

Yams respond well to heavy fertilization. Experiments carried out at IIHR, Bangalore have also indicated that D. floribunda responds well to Nitrogen. A complete fertiliser dose of 300 kg Nitrogen, 150 kg P_2O_5 and 150 kg K_2O per

ha is recommended. Phosphrous and Potassium are to be applied as basal dose at the time of planting. Nitrogen should be applied in two equal doses one after the establishment of the crop during May-June and the other during grand growth period of the crop (August – September). It is advisable to supply one third of the nutrients in the form of organic manures, and it has been found that organic manures give better results in tuber crop.

Irrigation:

The crop requires frequent irrigation in areas where rainfall is scanty or not well distributed. In the initial stages, weekly irrigations are required and the interval can be increased to 10-15 days at later stages of growth.

Harvesting:

Although tubers can be harvested at any time of the year, it is better to harvest the tubers when the plant are dormant to get maximum yield of diosgenin.The tubers are harvested manually, washed free of soil and dried in the sun. It is preferred to chop the tubers into small pieces before drying. Yield:

D. deltoidea - 5-7 tonnes of dry tubers per ha
D. floribunda - 6-8 tonnes of dry tubers per ha
Diosgenin content - 2.5 – 3% - I Year
3. 0 – 3.5% - II Year

RAUVOLFIA

Botanical name:	Rauvolfia serpentine
Family	: Apocynaceae
Origin	: India
Plant part	: Roots.

Importance:

Rauvolfia serpentine (Sarpagandha) is one among the most important medicinal plants native to India. The roots of the plant have been used in the indigenous system of medicine from 3000 years back. The roots of the plant were used for centuries by the Ayurvedic and unani system of medicine in India to treat various types of ailments, ranging from disorders of the central nervous system, such as mamiacan behaviour, insanity, snake bite, schizophrenia, epilepsy and to intestinal disorders, child birth etc.

Its importance in modern medicine (Allopathy) was recognised in 1952 only after the isolation of an alkaloid – Reserpine in the roots of the plant, which is used as anti hypertensive and sedative. Roots of Rauvolfia are available from Visakhapatnam and Srikakulam districts in AP.

The root owes its pharmacological activity to the presence of several alkaloids, of which reserpine is the most important. The total alkaloidal content of the roots ranges normally from 1.7 to 3.0%, which are mostly concentrated in the bark (about 90%)

Botany:

The genus Rauvolfia was named in honour of a sixteenth century traveler and botanist-Leonard Rauvolfia; serpentine refers to the long tapering snake like roots. Rauvolfia serpentia plant is an erect, small perennial shrub, seldom attaining a height of 1 m when cultivated.

Tap root is tuberous, soft sometimes irregularly nodular; bark pale brown corky with irregular longitudinal fissures.The plant is characterised by long elliptic lanceolate or obovate leaves occurring in whorls of three to five at the nodes. Flowers appear in corymbose cymes, flowers are white or pink. Under cultivation the plant flowers throughout the year but in nature flowering and fruiting are seen during May and October months only. In North India, plants shed leaves after October and sprout again during March-April. The fruit is a drupe, 0.6 cm in diameter, shining black when fully ripe.

Climate:

R. serpentine grows wild under a wide range of climatic conditions.It flourishes better in hot and humid tropical areas and can be grown in the open or partial shade. A range of temperature from 10-38^{0}C appears to be well suited to the plant. The plant grows naturally in areas receiving a rain fall ranging from 250-500 cm per annum. The tropical or sub tropical zones preferably with south- west monsoon rains are considered ideal, the area should be frost free. In South India, where equitable climate exists, the plant grows better than in the sub Himalayan tracts.

Soil:

It grows on a wide variety of soils.The soils on which it grows wild are acidic in nature having a pH of 4 to 5.The soils should be rich in humus have high water holding capacity but with good drainage.Its commercial cultivation is found in rich soils with 6 to 8.5 pH. Medium to deep well drained fertile soils, clay loam to silt loam soils rich in organic content are suitable for commercial cultivation.

Propagation:

Rauvolfia can be propagated by 1. seeds 2. stem cuttings 3. root cuttings 4. stumps.

Seed propagation: Usually propagated by seeds. Only heavy seeds, which sink in water should be used for sowing. The seeds must be collected from June to October for sowing. Seeds collected during other periods, don't germinate satisfactorily. The percentage germination is quite variable(10-50%).Two reasons are said to be responsible for poor germination

1. Stony endocarp of the seed may be responsible to some extent
2. But in many cases, the absence of embryo in the perfectly normal looking seeds due to either parthenocarpy or defective development of embryo.

About 8kg seed is sufficient to raise 1 ha plantation. Direct sowing of seeds in the main field is not successful and hence seedlings are raised in the nursery and transplanted in the field.

Raising nursery:

The nursery should be located preferably in partial shade with adequate irrigation facilities. The selected land is cleaned of all weeds and worked to a fine tilth up to a depth of 30 cm. The nursery beds are incorporated with FYM and leaf mould @
1 kg per square meter.Then the seed beds of convenient size with irrigation channels are laid out.

The seeds before sowing are soaked in water over night and treated with thiram @ 3 g per kg seed before sowing.Under North Indian conditions the seeds are sown in April – May, while shallow furrows (10-15 cm apart) 2-3 cm with in the row at a depth of 1.5 – 2 cm.After sowing the beds are covered with a mixture of FYM and fine soil.The beds are watered immediately and kept moist, there after by regular watering.

In areas of heavy rainfall it is preferable to sow the seeds in raised beds. Germination starts after 15-20 days and continues up to 40-45 days of sowing. Seedlings (40-45 days old) having 4-6 leaves are ready for planting in the main field.

Vegetative propagation:

a. Stem cuttings:Stem cuttings of 15-22 cm long with three internodes are considered ideal.The cuttings are planted in the nursery in June and kept moist until they sprout. Rooting of cuttings (hard wood cuttings) may be hastened by treating with IAA at 30 ppm for 12 hours.Roots appear with in 15 days.This method gives 40-65% success.

b. Root cuttings:

Root cuttings are taken from tap root as well as secondary roots. Root cuttings of 3-5 cm and 1to 1.25 cm thick are planted horizontally at 5 cm depth during spring and are covered with soil.The beds are kept moist through waterings. The cuttings sprout with in 3 weeks and a success of 50-80% has been obtained.About 100 kg of root cuttings are required to plant one ha of land. Method:

Seedlings (40-45 days old) of 7-12 cm height having 4-6 leaves are carefully lifted from the seed bed., avoiding injury to the long delicate roots, they are planted in rows at 60 x 30 cm spacing. A hole without bending the main root and the soil is then gently but firmly pressed. Immediately after planting the field is irrigated.

Irrigation:

Till the newly planted seedlings establish well, they are frequently irrigated. Although R. serpentine can be cultivated under rainfed conditions yields can be increased by irrigation particularly in low to medium rainfall areas. Plants may be irrigated at an interval of 7-15 days during summer and 15-20 days during winter, depending on the soil and climatic conditions.

Manuring:

Not much work has been so far on the fertiliser requirement of R. serpentine.The growth of the plants is reported to increase with the application of organic manures and fertilisers. Nitrogenous fertilisers, induce more vegetative growth but results in stunted root growth. But the combination of N and P results

in the better root growth. P induces greater root growth than N. Well rotted FYM @ 25-30 t/ha should be applied during land preparation. A basal dose of 20 kg N, 30 kg P and K per ha has to be applied. Two top dressings of N @ 20 kg / ha should also be applied during the growing season every year.

Harvesting:

The roots of Rauvolfia serpentine will be ready for harvesting from 15 months of 36 months, depending on the area of cultivation, and irrigation. Roots dry in winter when the plant is completely defoliated, as at this stage the total alkaloid content in the root is at its maximum. A light irrigation should be given one day prior to digging for easy unlifting of the roots. The roots are removed carefully with a spade with out damaging the bark of the root, as the bark has higher alkaloid content. The bark contributes 40-50% of the roots. The harvested roots are washed to remove the adhering soil and then air dried to reduce the moisture content from 60% to 8% for storage. This increases the keeping quality of the roots.

Yield:

The plants raised from seeds give maximum yield of roots than those raised vegetatively.

Seedlings – 1,175 kg/ha (rain fed air dry basis) Stem cuttings – 175 kg / ha (rainfed air dry basis) Root cuttings – 345 kg /ha (rainfed air dry basis)

LECTURE-24: Opium and stevia – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

OPIUM

Botanical name:	Papaver somniferum L.
Family	: Papaveraceae
Origin	: Western Mediterranean Region
Plant part	: Milky white latex unripe capsules

The Opium poppy Papaver somniferum is an outstanding medicinal plant, the products of which viz., opium and codeine are important medicines used for their analgesic and hyponitc effects. A semi synthetic derivative of this drug from morphine known as herion has led to world wide social problems. Its cultivation in India is confined to the states of Madhya Pradesh, Rajasthan and U.P.

Botany:

Papaver somniferum is an erect, rarely branched, glaucous annual, growing to a height of 60 – 120 cm. The leaves are ovate, oblong or linear oblong. Flowers are large usually bluish with a purplish base or white, purple or variegated. It produces capsular type of fruits from which the latex known as opium is obtained on lancing. The fruits are about 2.5 cm in diameter, globose in shape. Seeds are reniform with white or black in colour. Though nearly all parts of the poppy plant contain a white milky latex, the unripe capsules contain large amount.

Climate:

It is a crop of temperate climate but can be grown successfully during winter in sub-tropical regions. Cool climate favours higher yield, while higher day/night temperature generally affects the yield. Frosty or desiccating temperature, cloudy or rainy weather tends to reduce not only the quantity but also the quality of opium

Soil:

Opium poppy prefers a well drained, highly fertile, light black or loam soil with an optimum pH around 7.0

Varieties:

A large number of races of opium known by their local names are reported to grow in India. They usually vary in leaf characters, floral characters or capsular characters. Telia, Dholia are some of the local races recommended for commercial cultivation.

Preparation of land:

The field should be ploughed 3 or 4 times to produce well pulverized soil. The field is then prepared into beds of convenient size.

Sowing:

The seed is either sown broad cast or in lines. Before sowing, the seeds may be treated with fungicides like Dithane M 45 @ 4 g per kg of seed. Seed is usually mixed with fine sand before broadcasting to ensure uniform spread in the bed. Line sowing is preferred to broadcasting as the later method has many drawbacks like higher seed rate, poor crop stand and difficulty in carrying out inter cultural operations. The best time for sowing is late October or early november. Seed rate is 7-8 kg per ha for broadcast method and 4-5 kg per ha for line sowing. A spacing of 30 cm between lines and 30 cm between plants is normally adopted.

Manuring:

Opium poppy responds remarkably to the application of manures and fertilizers which increase both the yield and quality of opium. Farm yard manure @ 20-30 t per ha is generally applied by broad casting while the field is prepared for sowing. Besides 6-80 kg N and 40-50 kg P per hectare is recommended. No potash is applied. Half of N and entire P are applied at sowing time through placement and remaining half of Nitrogen is placed at rosette stage.

Irrigation:

A careful irrigation management schedule is essential to get a good crop of poppy. A light irrigation is given immediately after sowing followed by another light irrigation after 7 days when the seeds start germinating. Three irrigations at an interval of 12-15 days are given till pre flowering stage and then irrigation frequency is reduced at 8-10 days during flowering and capsule formation stage. Normally, 12-15 irrigations are given during the entire crop period. Any moisture stress during the stage of fruiting and latex extracting may reduce the yield considerably.

Lancing and latex collection:

Opium starts flowering in 95 – 115 days after sowing. The petals start shedding after 3-4 days of flowering. The capsules mature after 15-20 days of flowering.Lancing of the capsules exudes maximum latex at this stage. This stage can be visually judged by the compactness and a change in the colour from greenish to light green coloured ring in the capsule. The stage is called as industrial maturity.Lancing may be done with a knife having three or four equispaced pointed ends which does not penetrate more than 1-2 mm in the capsule. Too deep or too shallow incision is not advisable. Lancing may be done early in the morning before 8.00 am at two days interval in each capsule. The length of the incision should be 1/3rd or less than the full length of capsule.

Harvesting and threshing:

The crop is left for drying for about 20-25 days when the last lancing on the capsules stops exudation of latex. The capsules are then picked up and the plant is removed with sickles. Harvested capsules are dried in open yard and seeds are collected by beating with a wooden rod.

Yield: The yield of raw opium varies from 50 to 60 kg per ha.

Flowers are large usually bluish with a purplish base or white, purple or variegated.
It produces capsular type of fruits from which the latex known as opium is obtained on lancing.
Any moisture stress during the stage of fruiting and latex extracting may reduce the yield considerably.
Lancing and latex collection:
Opium starts flowering in 95 – 115 days after sowing.The petals start shedding after 3-4 days of flowering.The capsules mature after 15-20 days of flowering.Lancing of the capsules exudes maximum latex at this stage.
This stage can be visually judged by the compactness and a change in the colour from greenish to light green coloured ring in the capsule. The stage is called as industrial maturity.
The capsule is lanced longitudinally with a knife having three or four equispaced pointed ends which does not penetrate more than 1-2 mm in the capsule. Too deep or too shallow incision is not advisable. Lancing may be done early in the morning before 8.00 am at two days interval in each capsule. The length of the incision should be $1/3^{rd}$ or less than the full length of capsule. The yield of latex and its morphine content is maximum in first lancing and decreases subsequent lancing. The terminal capsule yields more latex than lateral ones. In Sanchita variety is for high morphine content in the straw, meant for solvent extraction of capsules, eliminating lancing in the field.
Harvesting and threshing: The crop is left for drying for about 20-25 days when the last lancing on the capsules stops exudation of latex. The capsules are then picked up and the plant is removed with sickles. Harvested capsules are dried in open yard and seeds are collected by beating with a wooden rod. The yield of raw opium varies from 50 to 60 kg per ha.

STEVIA

Botanical name:	Stevia rebaudiana
Family	: Asteraceae
Plant part	: Leaves

Importance:

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 and used in tonics for diabetic patients

Botany:

Short day plant and grows to height 45 cm within 3 months. However Stevioside yield more under long day conditions.

Soil and Climate:

Red sandy loam soils with 6-7 pH best. Heavy soils not suitable.Grows best in subtropical climate.

Propagation:

Seed germination is poor hence vegetatively by stem cuttings and tissue culture method was followed.

Planting:

Forming raised beds with15cm height 60cm width and planted with a spacing of plants 23 cm -30000 plants /acre

Irrigation:

It require year round supply of water hence frequent irrigation managed by micro sprinklers

Fertilizers: 110 : 45: 45 kg NPK/ha

Harvesting:

Flowering do not reduces Stevioside content. Leaves plucking along with entire plant with side branches leaving 10-15 cm from ground. First harvesting 4 to 5 months after planting subsequent every three months.

Yield: 3000 kg leaves/acre and Leaves contain 10-12% Stevioside on dry weight

LECTURE-25: Ocimum and periwinkle – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

OCIMUM

Botanical name: Ocimum sanctum	
Family	: Labiatae
Plant part	: Leaves, seeds, roots

Importance:

Plant contains phenols, Aldehydes, tannins, saponin and fats, essential oil components – Eugenol (71%) eugenol methyl ether (20%) also isolated terpeneurobsolic acid havoing anticancer properties.

Botany: Erect, herbaceous, much branched softly hairy plant

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

Soil:

Wide variety of soils from rich loam to poor laterite soils – saline, alkaline, slightly acidic. Well drained soil suitable for good growth and higher yields.

Climate:

Flourishes well under high rainfall with humid conditions. Long days and high temperatures favours good growth and higher yields

Propagation: Propagated by seeds and highly cross pollinated

Nursery: Generally nursery laid down on raised beds with 200-300 g seeds/ha. Seeds germinate within 8-12 days and seedlings ready 6 weeks or at 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:

In summer 3 irrigations/ month and totally crop needs 12-15 irrigations

Harvesting and Yield:

Harvesting at full bloom stage and first harvest 90-95 after planting and after 65-75 days intervals. Cut 15-20 cm from ground level.

Yield:

About 5 t /ha twice or thrice year and whole herb contain 0.1-0.23% essential oil. Oil yield 10-23 kg/ha

Periwinkle

Botanical name:	Catharanthus roseus
Family	: Apocyanaceae
Plant part	: Leaves, seeds, roots

Importance:

Periwinkle is a perennial ornamental herb found throughout India on waste lands and sandy tracts.It has medicinal importance owing to the presence of indole alkaloids raubasin (ajmalicine) and serpentine in its root which have anti-fibrillic and hypertensive properties.

The leaves contain two alkaloids viz., Vinblastine and Vincristine which form the constituents of patented cancer drugs and vincristine alkaloids are distributed in different parts of the plant but the roots contain the maximum (0.75 t to 1.20%) followed by the leaf (0.60 to 0.65%).

Botany:

It is a perennial herb, often grows in garden for its pink and white flowers which bloom throughout the year.It bears flexible long branches with simple opposite leaves. Flowers 2-3 in cymes, axillary and terminal clusters. Fruit is a cylindrical follicle with many black seeds.

Varieties:

There are no recognized varieties but there are three local types based on the colour of the flowers viz., alba with white flowers roseus with pink rose coloured flowers and ocillata with white flowers having rose purple spot in the center are recognized.

Climate and Soil:

The cosmopolitan distribution of the plant shows that it has no specific climatic requirements. Its natural environments are, however, tropical and sub- tropical areas. A well distributed rainfall of 100 cm or more is considered ideal for raising it as commercial crop under rainfed conditions.

Similarly, it grows on any type of soil except those which are highly alkaline or waterlogged. It grows wild in coastal area. Light sandy soils rich in humus are preferred for large scale cultivation of the plant.

Propagation:

The plant is propagated from seeds. Fresh seeds are preferable as they lose viability on long storage. Seeds can be sown directly in the filed or the plants raised in the nursery and transplanted later on. Direct sowing is to be done for plantations of a large area, as it reduces the cost of sowing. About 2 to 3 kg seed is required for raising one hectare. The seeds are mixed with sand about 10 times its weight for even distribution and are sown during beginning of monsoon in rows 45 cm apart.When the plants grow up they are thinned out leaving a distance of 25 to 30 cm between the plants.

For nursery sowing and transplanting, about 500 grams of seed sown in 200 square meters bed is required for producing seedlings for one hectare. The seeds are sown in well prepared beds during March or April in rows about 1.5 cm deep, covered with light soil and leaf mould mixture and are watered to keep the bed moist.

In about 10 days time the seeds germinate an in 2 months time (height 6-7 cm) they become ready for transplanting. In the field the seedlings are transplanted at a spacing of 45 cm x 30 cm or 45 cm x 45 cm.

Weeding:

The crop requires two weedings, the first one about 60 days after sowing or transplanting and the second one in another 60 days.

Irrigation:

The plant do not require much water as they have drought resistant capacity. In areas, where rainfall is evenly distributed throughout the year, no irrigation is required, but in areas where monsoon is restricted, 4 to 5 irrigations are required during the life of the plant to get good yield.

Manuring:

They are not generally manured, however, for getting a good yield of both leaves and roots, farm yard manure at about 15 tonnes per ha should be applied and a fertilizer mixture of N (50 Kg), P_2O_5 (75 Kg) and K_2O (75 Kg) per hectare is applied as a basal dose.

Harvesting:

The crop becomes ready for harvest of roots after one year. But two leaf strippings can be taken, the first one after 6 months and the second after 9 months of sowing. Third stripping of leaves can also be taken when the whole plant is harvested after one year. For seed collection, matured fruits are hand picked and dried in shade and threshed lightly. This method ensures mature seeds with even germination. But the usual practice is to uproot the plants, dry them in shade and thereafter thresh lightly for seeds. The seeds obtained by this method, are not uniform and their germination is poor.

For harvesting of roots, the crop is cut about 7.5 cm above the ground and dried for stems, leaves and seeds and then the whole field is copiously irrigated and ploughed and the roots are collected. The roots are washed well and dried in shade and later made into bundles for marketing.

Yield:

Under rainfed conditions about 0.75 tonne of roots, 1.0 tonne of stems and 2 tonnes of leaves (all dry basis) may be obtained from one hectare. But under irrigated conditions, 1.5 tonnes each of roots and stems and 3 tonnes of leaves per ha can be obtained.

LECTURE-26: Aloe and solanum – introduction – botany – varieties – propagation – climate – soil – preparation of land - planting – irrigation – manuring – intercultivation – harvesting – yield

ALOE

Botanical name:	Aloe vera and Aloe barbadensis
Family	: Liliaceae
Origin	: Eastern and Southern Africa
Plant part	: Leaves, seeds, roots

Importance:

Two major products from leaves 1. Yellow bitter juice specialized cells , beneath epidermis yields drug aloe. 2. Parrenchyma tissue of centre of leaf contain mucilaging gel yield aloe gel obtained from A.barbdensis. Aloe also having anthro glycosides – Barbaloin – 4.5 to 25% and aloin. Aloe gel contains gluco mannan which is a polysaccharide similar to guar used in preparations of burn, first aid medicines also used in laxative preparations

Botany:

Perennial herb, shallow rooted and does not have true stem with multiple tuberous roots. It does not produce many viable Seeds as it is a male sterile plant

Varieties: Aloe vera var chinensis is commonly cultivated one

Soil:

Hardy and grown on variety of soils, does well in sandy coastal and loamy soils with pH upto 8.5. Water logged and problem soils not suitable

Climate:

Wide adaptability hence cultivation possible throughout country and prefers warm humid dry climate with 150-200 cm to 35-40 cm yearly rainfall

Propagation: Root suckers or rhizome cuttings

Planting: 15-18 cm long root suckers, rhizome cuttings are planted with a spacing of 60 x 30 cm or 60 x 45 cm and buried 2/3 portion under the ground.

Manuring: 150 kg/ha mixture of NPK

Irrigation: Immediately after planting needs one irrigation and totally 4 to 5 irrigations / year required.

Harvesting:

Plants removed by manually or with tractor after eight months after planting

Commercial yield from second year to upto five years

Yield : Fresh weight 10000 – 12000 kg/ha

SOLANUM

Botanical name:	Solanum khasianum
Family	: Solanaceae
Origin	: India
Plant part	: Berries

Importance:

Solanum khasianum serves as a supplementary source of steroidal raw material for industries in India. Solasodine obtained from its berries are used as a substitute for diosgenin in the synthesis of steroidal hormones.It is used in the manufacture of oral contraceptive tablets. The extract also possesses some nematicidal and bactericidal properties.

The genus Solanum comprises of about 2000 species which can broadly grouped as tuberous group and non-tuberous group. S. viarum belongs to the latter group and is native of India and occurs in nature in Sikkim, West Bengal, Orissa and in Western Ghats up to 1600 m MSL. The solasodine content in the berries varies from 1.00 to 1.75%.

Botany:

It is a stout, much branched undershrub varying in height from 0.75 to 1.40 m with moe of straight prikles often mixed with a few curved spines on the stem. Leaves are ovate, lobed, hirsute and prickly on both the surface. The flowers are white, borne in racemes with 1-4 flowers and the berries are yellow or green in colour, globose in shape.

Varieties: RRL, Jammu has identified two mutants which are high yielding with high solasodine content.

1.RRL – 20-2: It is vigorous in growth with 3-4 fruits per node, with a yield potential of 6-7 tonnes of fruits and 42-45 kg of solasodine/ ha.

2. RRL-SL-6: It is a spineless mutant. It is almost similar to RRL – 20-2 in all aspects except having slightly reduced solasodine content.

3. Arka Sanjeevin: It is a high yielding variety developed by IIHR, Bangalore.

Seeds and Sowing:

S. khasianum is either directly sown or transplanted. For transplanted crop, seeds are sown in seed bed in February – March. The seeds are sown in lines 10 cm apart and covered with a thin layer of soil. The seed beds should always be kept moist by sprinkling water as and when necessary. Scarification of seed with 5% nitric acid improves the germination of the seeds. About 1.25 kg seeds provide enough seedlings for planting one ha of land. Germination is complete in 7-10 days. 4-5 weeks old seedlings having about six leaves are ready for transplanting. Seedlings may be transplanted in moist soil at a spacing

in 50 x 50 cm. For intercropping and easy cultural operations, a wider spacing of 90 x 150 cm is ideal.

Manuring:

S. khasianum responds to the application of manures and fertilizers.Nitrogen, phosphorus and Potash at the rate of 100,60 and 40 kg per ha is recommended.

While the entire quantity of P and K are applied at the time of field preparation, N is generally applied in three splits at different intervals.Irrigation is generally done initially and subsequently the crop is grown as rainfed.

Irrigation: In general, a moisture stress inhibits vegetative development, fruit production and yield but the solasodine content increases with moisture stress.

Harvesting and Processing:

Harvesting is one of the difficult operations in the cultivation of S. khasianum. The spiny nature of the plant hampers plucking of fruits and hence the use of gloves is helpful. Plucking berries at the right stage of maturity is very important. The solasodine content increases consistently from the early stages of fruit development and attains a maximum when the fruit colour changes from green to yellow and it is considered as the right stage for harvesting the berries.

Berries contain 70-75% solasodine and 60% of this is present in the seeds and the rest 40% in the pericarp. Water content in the berries is about 70-75% percent and hence it should be dried immediately As slow drying causes a loss in solasodine due to degradation, oven drying is suggested. To hasten drying and to impart better colour, fruits are cut into halves and spread in thin layers on the floor and turned frequently. When the dried berries make cracking sound they are packed in bags. Dried berries should possess not more than 10-12 percent moisture and not less than 2 percent solasodine. 60% of the alkaloid is in seed and 40% of the alkaloid is in pericarp.

Yield: Fresh berries – 10t/ha Dry berries – 2t /ha
Solasodine content – 2.5%

LECTURE-27: Nuxvomica and guggal – introduction – botany – varieties – propagation – climate –soil –preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

Nuxvomica

Botanical name: Strychmus nuxvomica	
Family	: Loganiaceac
Origin	: India
Plant part	: Seeds

Nuxvomica also called as Poision nut, Snake wood, Mushini or Vishamushti

Importance:

The dried ripe seeds of Strychnos form the chief botanical source of the valuable alkaloids. They have acquired more as a poison than for medication. The use of Strychnos as a virulent arrow poison (curare) has been known since antiquity. The medicinal and toxicological properties of the drug are mainly exhibited by the alkaloid Strychnine. The drug is used for treatment of nervous disorders and paralysis in minute dosages. Higher dosages are employed in destroying stray dogs and Agricultural pests such as rats, rabbits, foxes etc Botany:

The plants are woody vines or small trees which bear large berries resembling a mandarin or Chinese orange in shape and colour each fruit containing three to five greyish seeds. The seeds are hard, large, circular or flattened structures having a bitter taste. The silky white sheen or luster of seeds is due to the presence of many closely oppressed hairs.

Seeds are removed from the glutinous pulp either by washing or allowing the pulp to rot away. After thorough washing and drying the seeds are marketed. The seeds contain a high percentage of alkaloids 1.53 – 3.42% and are the principal sources of drug. Other plant parts such as old roots, wood, bark, leaves blossoms and fruit pulp also contains varying amounts of alkaloids.

Climate:

Nux vomica occurs in UP, Bihar, Orissa, coramandel coast, A.P and Mysore and is most common in the monsoonal forest along the western coast. Tree is found growing in regions where the absolute maximum shade temperature varies from 35 to 45 degrees and minimum from 4 to 18^0C . Preferable rainfall range is 75 to 375 cm.It is a shade bearer growing under semi ever green forests.

Soils: Comes up well in clayey loam soils with ideal soil pH is 6.5 – 7.0 and 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. 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

Manuring:

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

Harvesting :

The plant comes to flowering and fruiting after 5 years and the matured fruits change the colour from green to yellowish orange. The seed can be extracted from the fruits by cutting and cleaning.

Yield: Seed yield – 4-5q/ha

GUGGAL

Botanical name: Commiphora mukul
Family : Bureraceae
Plant part : Bark - Oleogum resins

Guggal or Indian bedellium is a small tree and source for oleo gum resin which was tapped by making incision of bark. Resin occur in vascular or stalactite pieces, pale yellow brown or dull green colour with bitter, aromatic taste and balsamic odour. Oleogum resins mixtures of resin (61%) gum (29.3%), volatile oil (1.45%). Largely used in fixative in perfumes and medicines.The oleo resin – increases leucocytes in blood.

Botany: Tree or shrub grow 3-4 high and branches crooked, knotty, aromatic- end in sharp spines. Bark is papery and peels in strips

Varieties:

Marusudha- high yielder

Soil:

Not grown on commercial scale. Naturally in western India of sandy , silt and loam with poor in organic matter. Average soil suitable for cultivation

Climate:

Wide adaptability and arid regions with varying conditions. Prefers a warm, dry climate for higher yield of oleogum resin

Planting: Pits at a spacing 3 to 4 m in rows.

Propagation: Seeds and vegetatively by stem cuttings. Air layering is successful

Seed:

Poor germination, slow growth and hard seed coat due to all these reasons seed is not a common propagation method.Mechanically scarified by rubbing with sand paperand kept in running water (24 hours).Raised in poly bags.

Stem cuttings:

15-20 cm long and 10 mm thick semi hard wood cuttings are treated with GR(IBA or NAA) and planted in beds. Cuttings sprout in 10-15 days and redy to transplant within 10 -12 months and percentage of rooting 80-94%.

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

Irrigation: Light irrigation in summer results good growth of Plant

Gum tapping and Yield:

1. Normal height after 8-10 years tree is ready for tapping
2. Tapping gum from balsam canals of phloem
3. Shallow incision on bark. Too deep leadsto plant may die or low yield next year
4. Making incision – small quantity guggal gum mixed applied to incision place by using prick chisel
5. Sharp chisel dipped in guggal solution and incision is made
6. Incision is made after November – Before April
7. Resin collected 10-15 days interval
8. 700-900 g/plant

Separation of resin from gum:

Hot expression or solvent extraction at 120- 130^{0}C

LECTURE-28: Aonla – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

Botanical name:	Emblica Officinalis Phyllanthus emblica
Family	: Euphorbiaceae
Plant part	: Fruits

Introduction:

Very rich in vitamin C and used in medicinal and Ayurvedic treatments. Aonla fruit contains tannins like gallic acid, allagic acid, glucose in its molecules which retards oxidation of vitamin C and antisaorbustic in fresh and dried fruits. Fruits useful in haemorrhaeges, dysentery, anaemia, jaundice, dyspepsia and cough. Important in Triphala and chavanaprash and great health vitality restorer.

Botany:

Tree of medium height evergreen in tropics but deciduous in subtropics and type of branching is called as Phyllanthoid branching

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 and tolerance to salinity and sodicity. It prefers subtropical with distinct winter and summer

Propagation: Budding, grafting and seed

Planting:

Beginning of monsoon with a spacing of 8 to 10 m both ways. After first rain plants are planted

Irrigation:

Hardy stand well against drought and may benefit – two irrigations at flowering and fruit set

Harvesting

Vegetatively propagated plants were ready for harvesting after 6-8 years and Seedlings 10-12 years with a productive life of 50-60 years. Fruits bearing during November /December and maturity judged by change of seed colour from creamy, white to black and translucent exocarp.

Yield: 60 to 70 kg fruits/tree

LECTURE-29: Senna – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

Botanical name: Cassia angustifolia	
Family	: Leguminosae Origin
	: South Africa
Plant part	: Leaves and pods

Introduction:

The leaves and pod of Senna contain sennosides A, B, C, D which are well known for the preparation of laxatives and purgatives all over the world. India holds leading position in the production of senna crop and export of its produce to the world market. Almost all the senna leaves produced in India are exported to foreign countries and the major portion is transported to London market. The crop is grown mainly in Southern districts of Tamil Nadu viz., Tirunelveli, Ramanathapuram and Madurai districts.

Botany:

Cassia angustifolia is an erect shrub seldom reaching more than 70 cm in height. The leaves are pinnate with narrow acute lanceolate and glabrous leaflets. The flowers are brillinantly yellow in colour and borne in recemose inflorescence. The pods are flat thin and contain 5-7 dark brown seeds. Although all parts contain sennosides, the leaves and pods contain maximum content. It ranges from 1-5.3% in India senna. The Alexandrian senna (C. acutifolia) which grows wild in Africa and Sudan contains 4 – 4.5%.

Climate and Soil:

Senna is a legume but produces no nodules for fixing atmospheric nitrogen. It grows well on sandy loam with a pH ranging from 7 to 8.5. It is very sensitive to waterlogged conditions, heavy rainfall and low temperature. Once established, the crop with stands moderate saline conditions.

Land preparation and sowing:

The land should be ploughed and exposed to sun for 2 to 3 weeks. The lands are so prepared to provide outlet for excess rain water at early growth period. Seed rate is 5 kg per ha. Treatment of the seeds with protective fungicides (thiram, captan or agrasan @ 2.5 g per kg of seeds to protect against damping off) and sowing at the optimum time and proper depth are the three most important factors which ensure a good and uniform plant population in the field.

The seeds are sown in line at 30-40 cm apart at 1.5 to 2.0 cm depth. Light pre monsoon showers helps in germination and initial establishment. Germination commences in 13 to 15 days of sowing and is over in another one week. The seed has a thick seed coat and can remain in field in hot weather without any injury but sprouted seed can seldom withstand the lack of soil

moisture and usually dies. The crop is thinned at 30 days to maintain a plant to plant distance o 30 cm in the rows

Manuring:

In general, 80 kg of N and 40 kg of P_2O_5 may be applied to this crop. Of this, 40 kg of nitrogen and the entire dose of P_2O_5 may be given at sowing and is placed at 4 – 5 cm deeper below the seed so that it is easily available to the growing seedlings. The remaining quantity of 40 kg of nitrogen is given 35 to 40 days (just after thinning), 80-85 days, and 105 -11- days age (i.e. after first and second picking of the leaf crops) in equal doses. Urea may preferably be used by broadcasting in rows and mixed thoroughly in the soil.

Irrigation:

Senna could be economically grown under rainfed conditions. An average rainfall of 25 to 0 cm, distributed from June to October is sufficient to produce good harvests. As irrigation leads to improvement in the yield, wherever easily available, it is given at 40 days, 75 days and 100 days age when plants bear new growth of foliage and flowers.

Harvesting:

Young senna leaves and pods contain a high sennoside content but since the produce is sold on the basis of weight, a balance between weight and content is to be made to choose its stage for harvest. First picking starts at 50 to 70 days age, depending upon total plant growth. A second picking be taken at 90 to 100 days and the third picking between 130 to 150 days when the entire plants are removed so that the harvested material includes both leaves and pods together. Although, root-bark contains sennoside, it has not yet come as an article of trade. The harvested crop should be spread in a thin layer in open area to reduce the moisture.

Further drying of the produce is done in a well ventilated drying sheds. It takes 3 to 5 days to dry the produce in the sheds. The dried produce usually possesses 8 per cent moisture. The properly dried leaves and pods should have light-green to greenish yellow colour. Improper and delayed drying changes the colour to black to brown which lowers the sennoside content and thus the price. Seeds contain no sennosides and it adds weight to the produce only.

Yield:

A good average crop of senna can give 1500 kg per ha of dry leaves and 700 kg per ha of pods under irrigated and good management conditions. The yield under rain fed conditions is about 1000 kg of leaves and 400 kg of pods.

LECTURE-30: Coleus and plantago – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

COLEUS

Botanical name:	Coleus barbatus
Family	: Limiaceae
Plant part	: Tuberous roots

Introduction:

Tuberous roots are rich source for forskolin and is a Drug for hypertension, glavcoma, asthma, congestive heart failures and cancers. Tuber roots resembles carrot in shape and brown in colour

Botany:

Aromatic perennial herb with 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 and well drained soils with a pH 5.5-7

Climate:

Crop of tropics and require humid climate with RH 83-95% and temperature 10-25^{0}C. If it is irrigated crop perform well in less humid and warm regions

Propagation: Propagated by seeds and stem cuttings.

Nursery:

Very poor germination (8-10%) and take 15-20 days for germination, 45 days old seedlings with 8- 10 cm height are ready for transplanting to main field.

Vegetative propagation:

Through terminal cuttings of 10-12 cm long cuttings with 3-4 pairs of leaves are planted in prepared nursery beds and after one month sufficient rooting may observed and ready for transplanting to main field

Planting: during June – July on Ridges and furrows at 60 x 20 cm

Manuring : 40 kg N, 60 kg P_2O_5 and 50 kg K_2O /ha

Irrigation :

Immediately after transplanting after that one in three days interval irrigation required.

Harvesting : Ready for harvest 41/2 – 5 months after planting and plants loosened uprooted, tubers separated, cleaned and sundried for extraction forskolin

Yield:1500-2000 kg/ha dry tubers

ISABGOL (Plantago)

Botanical name:	Plantago ovata
Family	: Plantaginaceae
Plant part	: Seeds and husks

Introduction:

Isagbol or Psyllium is important for its seed and husk which have been used in the indigenous medicine for many countries.It has the property of absorbing and retaining water (40-90%) and therefore it works as an anti- diarrhoea drug. It is beneficial in chronic dysenteries of amoebic and basillary origin.The seed has also cooling and demulcent effect and is used in ayurvedic, unani and allopathic medicines. The husk yields a colloidal mucilage consisting mainly of xylose, arabinose and galacturonic acid.

Botany:

It is a stemless annual herb often attaining a height of 30 – 40 cm, with rosette leaves. The plant bears erect ovoid or cylindrical spike with minute white flowers about 45 – 68 protogynous. Fruit is capsule, each seed is encased in a thin, white, translucent membrane, the husk, which is odourless and tasteless. Climate and soil:

It requires cool and dry weather and hence in India, the crop is grown in winter i.e. from November – December to March-April. Humid weather at maturity results in shattering of seeds. A light well drained sandy loam to rich loamy soil with a pH of 7 – 8 is ideal.

Varieties:

Gujarat Agricultural University has released two improved varieties viz., Gujarat Isabgol – 1 and Gujarat Isabgol -2 which have a yield potential of 800 – 900 kg and 1000 kg per ha respectively.

Preparation of land:

Field must be free of weeds and clods and should have fine tilth for good germination.The land is laid into flat beds of convenient sizes i.e. 1.0 m x 3.0 m or 2.5 m x 2.5 m

Sowing:

Fresh seeds from the preceding crop season should be sown for getting high per cent germination. The seed rate varies from 4 – 6 kg and is sown after pretreatment with thiram @ 3 g per kg of seed to protect the seedlings from the possible damage of damping off. The seeds, being small and light are mixed with sufficient quantity of fine sand before sowing. The seeds are sown broadcast and are swept lightly with a broom in one direction to cover them with some soil.

After cultivation:

Timely weeding is important to encourage good growth of the plants. After 20-25 days of sowing, first weeding is done and 2-3 weedings are required within 2 months of sowing.

Manuring: 25 kg N/ha and 25 kg P/ha are applied as basal dose at the last Ploughing and another dose of 25 kg N/ha is top dressed 30 days after sowing.

Irrigation: Immediately after sowing light irrigation is essential. First irrigation should be given with light flow of water. The seeds normally germinate in 6 – 7 days.If the germination is poor, second irrigation may be given. Later on, irrigations are given as and when necessary.Last irrigation should be given at the time when maximum number of spike have reached the milk stage.

Harvesting and processing:

The crop will be ready in about 110-130 days after sowing. When mature, the crop turns yellowish and the spike turns brownish. The seeds are shed when the spikes are pressed even slightly. At the time of harvest, the atmosphere must be dry and there should not be any moisture on the plant. The plants are normally cut at the ground level or are uprooted if the soil is loose textured.

The harvested plants are threshed and winnowed, and the seeds repeatedly sifted until clean. The seeds may be marketed whole or the husk may be sold separately. Seeds are fed to a series of shellers, in each sheller the grinding pressure is so adjusted to remove only the husk. This is separated by fans and sieves at each sheller and the ungrounded material is sent to the next sheller.

The husk: seed ratio is 25:75 by weight. The average yield is about one tonne of seeds per hectare.

LECTURE-31: Acorus and belladonna – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultivation – harvesting – yield

ACORUS (Sweet Flag)

Botanical name:	Acorus calamus
Family	: Aeraceae
Plant part	: Dried root (rhizome)

Introduction:

Dried root (rhizome) of sweet flag used in medicinal preparation and flavouring liquors. Contains volatile, yellowish brown oil with pleasant and slightly sweet odour called Calamus oil which was extracted by steam distillation. Calamus oil having expectorant action used remedy for asthma.

Botany: Monocot plant , herb with narrow leaves

Species/Varieties:

Acorus gramineus – Japanese species

Acorus Calamus – India and Srilanka

Soil: Clayey loam soil and light alluvial soils of river bank are excellent for acorus cultivation.

Climate: Hardy plant, grows in tropical to subtropical climates and requires well distributed rainfall throughout year

Planting Season:Best season March-April

Propagation: Live ends or tops of previous crop used as propagating material Planting: Recommended spacing 30 x 30 cm and rhizome pieces presses into mud to a depth of 5cm

Manuring:

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

Irrigation: Regularly irrigated and 5 cm water left standing in field and also increased 10cm as plant grows

Harvesting and Yield: After one year crop is ready for harvesting, field partially dried and sufficient moisture observed go for necessary deep digging. Leaves turn yellow, dry are the indicative of maturity. Rhizomes located at 60 cm depth and 30-60 cm long so harvesting carefully. Rhizomes cut into short lengths of 5-7.5 cm and fibrous roots were removed. Pieces are washed and dried in sun. Dried material rubbed in gunny bags to remove scales.

Yield: 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.

BELLADONNA

Botanical name:	1. Atropa belladonna (European belladonna) 2. Atropa acuminate (Indian belladonna)
Origin	: 1. Central and Southern Europe 2. Western Himalayas.
Family	: Solanaceae
Plant part	: Leaves and roots

Introduction:

Belladonna is one of the most important plant drugs, used in modern medicine throughout the world. Because of its sedative and antispasmodic action, the drug is used in a number of formulations both in the form of crude extract and pure alkaloid. The main alkaloids are Hyoscyamine and Atropine. Belladonna is used mainly as extract, tincture or plaster or in the form of total alkaloid.

The commercial drug is obtained from the leaves, tops and roots of both species of Atropin. In India, the cultivation of belladonna is confined to Jammu and Kashmir.

Botany:

A. belladonna is a perennial herb.It grows to a height of 1.5 m, It branches freely and possesses strong root systemLeaves are ovate or obovate, acuminate with small petiole, alternate or in pairs of which one is smaller than the other.

Flowers are borne in the axils (2-4) during June to September. Flowers are large, bell shaped with violet brown veins.Fruits are globular, shining, purplish black, many seeded berry.

Indian belladonna (A. acuminata) is an erect growing large herb with dichotomously branched system. Leaves are green or olive green in colour. Flowers are axillary and solitary with dull yellow colour. Fruits are globular and purple black in colour. It occurs wild in open forests between 1800 to 3000 m in elevation in the western Himalayas. Both the species are more or less similar except for the shape of leaves and colour of flowers.

Climate:

Belladonna grows up to an elevation of 1400 m.It is a temperate crop, can be grown as a winter crop in sub tropical areas. In temperate climate the plants behave as perennial and give maximum yield of herb and alkaloid. Hence, temperate climate is ideal. In nature, it is found to grow both in open as well as under partial shade conditions. It requires a dry weather during picking for high alkaloid content and its rapid drying.

Soil:

It grows well in deep fertile soils of medium texture and rich in humus. Heavy clays, which are prone to water logging conditions, should be avoided. Soils with slight acidic nature are more suitable.

Propagation:

Can be propagated both by seed and vegetative means (stem and root cuttings). But commercial propagation is done by seed only. Belladonna can be raised either by direct sowing in the field or as a transplanted crop. Nursery site is brought to fine tilth and raised beds of 75 x 100 cm size are laid out with irrigation and drainage channels. Prior to sowing well rotten FYM or sheep manure is incorporated in to the soil. Then the seeds are broadcast on the beds or sown in rows and covered with a layer of leaf compost or FYM or mulched with paddy or wheat straw. The beds should be irrigated immediately and thereafter regularly.

Time of nursery sowing:

The belladonna nursery is raised twice in a year once in early summer (May – June) and next in autumn (September – October).

Seed rate:

The seed rate is 4 kg which produces sufficient number of seedlings per ha. Germination of belladonna seeds is slow and erratic and varies from 15 to 40%. The seeds of belladonna require pre chilling (stratification) before sowing to improve germination. Alternately, seeds may be treated with ethyl alcohol for 3 hrs or with petroleum for 6 hours for improving the germination percentage. Soaking of seeds for 24 hours in 100 – 1000 ppm GA_3 stimulates early germination. Seeds may also be treated with Captan or Dithane Z 78 (10g/kg seed) to check damping off. Germination will be over with in 30 days and the seedlings will be ready for transplanting in the main field after 8 – 12 weeks of sowing.

Planting in the main field:

Seedlings of 8-12 weeks old are transplanted in the main field either in early spring (March – April) or autumn (October – November). Generally, seedlings raised in autumn are planted in spring and those raised in summer are planted in autumn. Seedlings are planted on ridges spaced at 60 to 70 cm and at 50 – 60 cm on the ridge.

Irrigation:

Belladonna has a high water requirement. It should be irrigated frequently during the dry period particularly. Normally 6-7 irrigations during June to September are required. The interval may be 10-15 days depending upon the soil texture and rainfall.

Manuring:

Belladonna is a soil exhausting crop and requires applications of heavy doses of manures. Under Kashmir conditions, 60 kg P_2O_5, 30 kg K_2O and 40 kg N per ha along with 25 tons of FYM as basal dressing is applied. As top dressing 80 kg N in 4-5 splits at monthly intervals after every harvest is given. Heavy doses of nitrogen are necessary to get good crop of leaves and high alkaloid content. Nitrogen should be supplied through Calcium Ammonium Nitrate. Basal dose of N, P and K should be repeated every year in spring (March – April) followed by top dressing of Nitrogen. Immediately after the application of fertilizers the crop should be irrigated. Irrigation also helps in the translocation of alkaloids from root to the leaves.

Harvesting:

The alkaloid is present both in leaves and roots, but more in leaves. Leaves contain maximum amount of alkaloid during early flowering stage. It gets progressively reduced till the formation and ripening of fruits. The best time for harvesting the leaves would be as soon as the shoots start flowering. Tender, terminal portions of the branches along with leaves are cut by hand sickles and chopped into pieces dried in the sun. The first crop of leaves is available three months after planting. Within a month of first harvest, there will be fresh growth ready for second harvesting. During the first year, 3-4 harvests are obtained.

In the second year and third year 3-4 harvests are taken. After three years the roots are also harvested.

Drying:

Harvested and chopped leaves are spread in thin layers on tarpaulin and dried under sun for 2-3 days. Regular turnings must be given to prevent deterioration of leaves. A well dried crop retains its green colour. The crop during drying looses about 70-80% of its weight.

Yield:

Initial yields are poor because of less number of branches. Yield of leaves increases after the first cutting.

I year: 600 kg of dry leaves per ha

II and III year: 1500 kg of dry leaves per ha

IV year: 200 – 300 kg of roots per ha

Chemical constituents:

Roots - 0.5% alkaloid

Leaves - 0.35% alkaloid

LECTURE-32: Aswagandha – introduction – botany – varieties – propagation – climate – soil – preparation of land – planting – irrigation – manuring – intercultiation – harvesting – yield

Botanical name:	Withania Somnifera
Family	: Solanaceae
Plant part	: Leaves and roots
English name	: Winter cherry

Introduction:

Among 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 having antibiotic and antitumor properties. Paste from leaves used for curing inflammation of tubercular glands. Fruits and seeds are used for diuretic problems and chest complaints. Fruit is berry turn orange red when mature

Varieties

Jawahar aswagandha -20- JNKVV mandsur

Soil:

Sandy loam or light red soils with good organic matter are best soil and are easy to dig roots in this condition

Climate:

Requires subtropical climate, preferably dry weather and it needs 1-2 winter rains for full development of roots.

Propagation: 2 methods

1. Directly sowing the seed
2. Raising seedlings

Direct sowing:

Seeds are directly broadcasting with a seed rate of 10-12 kg/ha during second week of July.

Nursery raising and planting:

Seedlings are raised in a raised nursery bed with 5 kg seed to provide ha. Seeds treated with fungicide and seeds sown in nursery spaced at 5 cm. Germination in 6-7 days and six week seedlings are ready for transplanting with a spacing 60 x 60 cm.

Manuring:

Does not require heavy doses of manures

Interculture:

Directly sown crop thinned 25-30 days to maintain a population of 20,000 to 25,000/ha

Harvesting and Drying:

Harvesting from January to March at 150-170 days after transplanting and drying of leaves, change of berry colour to orange red were the maturity indices.Entire plant uprooted and roots separated by cutting 1-2 cm above crown, transversely cut into smaller pieces 7-10cm for drying and occasionally roots dried as whole. Berries plucked from dried plants threshed to obtain seeds

Yield:

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

CROP-WISE AREA, PRODUCTION AND PRODUCTIVITY OF MAJOR SPICE CROPS IN INDIA DURING 2007-08, 2008-09 AND 2009-10

Area in 000 HA, Production in 000 MT and Productivity= MT/HA

	200H18				2008-()9			2009-10	
	MEA	PRODUC110N	PDY.	NV.	PROOUCTIOU	PDY.	MEA	PRODOC110N	PDY.
Cllnles	008.17	1294.15	1.6	77905	1:N!1.85	1.6	767.23	1211!.94	1.6
Gac	206.12	1008.50	5.2	166.21	831.10	5.0	1&1.86	833.97	5.1
Tunreric	174.51	794.19	4.6	18.09	821.16	4.5	18096	792.98	4.4
Ginger	104.36	30008	3.7	108.64	300.10	3.5	11J7.54	385.33	3.6
O:Jiarvi;r	364.21	229.95	0.6	300.85	242.13	0.6	360.00	236.72	0.7
Tamarind	55.04	182.08	3.3	54.63	177.68	3.3	57.$	185.46	32
QJmin	429.38	172.47	0.4	429.38	172.47	0.4	377.Ql	156.33	0.4
Fenugeel<	55.20	55.48	1.0	6129	7658	1.1	43.25	57.44	1.3
Fennel	54.29	67.78	1.2	47.16	6429	1.4	50.67	56.55	1.1
f"eR8	197.33	47.01	0.2	238.71	47.«l	0.2	195.92	51.(12	0.3
CilJt1anun	81.93	13.65	0.2	91.$	15.45	0.2	9D.20	15.72	02
othersji:es	17.71	1Q.71	0.6	17.71	1D.71	0.6	19.11	13.04	0.7
Ajllan	19.29	11.12	0.6	19.59	16.41	0.8	17.06	10.27	0.6
Nut1T9J	15.26	11.37	0.7	1527	11.37	0.7	15.06	8.00	0.S
Tejpat	2.45	5.29	22	2.44	4.00	2.0	3.24	7.00	2.2
ClnnaJ!01	0.87	1.67	1.9	0.88	1.67	1.9	1.00	1.67	1.7
Cb'le	2.25	1.01	0.4	2.57	1.33	0.5	2.60	1.16	0.4
Olhels(2)	9.01	0.23	0.03	9.01	0.23	0.03	9.34	0.24	0.00
Total	2617.36	4356.71	1.7	2629.44	4144.91	1.6	2463.29	4015.91	1.6