Theory Notes

Course No.: PSMA-121 (New)

Course Title: Commercial Production of Spices and Plantation Crops

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- These notes are based on New 6th Dean Committee Syllabus.
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Introduction

Spices and condiments constitute an important group of Horticultural commodities, which, since antiquity, have been considered indispensable in the culinary arts for flavouring foods. Some are used in pharmaceutical, perfumery, cosmetics and several other industries, and others possess colourant, preservative, antioxidant, antiseptic and antibiotic properties. Besides, they also play quite a significant role in the national economy of India and also in those of various other spiceproducing, exporting and importing countries of the world. According to the International Organization for Standardization (ISO) report, there are about 109 spices grown in different parts of the world. India grows more than 60 spices.

Definition

The term 'Spices and Condiments' are natural plant products or mixtures used in whole or ground form as food adjuncts, mainly for imparting flavour, aroma and pungency to foods. It is also used for seasoning of foods and flavoring of beverages.

Spices are natural plant products used to improve the flavour, aroma, taste and colour of food products; they are also used in beverages, liquors, and pharmaceutical, cosmetic and perfumery products. From time immemorial, India has been known as the 'Land of Spices'. No other country in the world has such a diverse variety of spice crops as India. Indian spices are renowned for their excellent aroma, flavour and pungency, not easily matched by any other country. Even in minute quantities, spices are a real delight to the senses, making food more palatable, tasty and easily digestible. While, their usage is common in one form or the other in every household, their demand in the food processing industry is increasing at a rapid pace across the world. Thus, the demand for spices in recent years has been continuously growing.

Spices

- Spices are those plants, the products of which are made use as food adjuncts to add aroma and flavour.
- Spices are the substances which obtained from strongly flavored or aromatic parts of plants such as roots, rhizomes, leaves, stem barks, flowers buds, seeds, fruits etc. These are mainly used in small quantities in food as a food additive for the purpose of flavour, colour or as a preservative that kills harmful bacteria or prevents their growth. These are also used in medicine and cosmetic product preparation.
- The term 'Spices and Condiments' are natural plant products or mixtures used in whole or ground form as food adjuncts, mainly for imparting flavour, aroma and pungency to foods. It is also used for seasoning of foods and flavouring of beverages.

Condiments

- The term "condiment" originally meant seasoned, pickled, or preserved foods in Latin. Today, the word is broadly applied to a variety of foods, including spices, herbs, sauces, seasonings, flavorings, colorings, and even beverages, such as tea, coffee, and alcoholic drinks. A more narrow definition is that a condiment is a substance added to other foods for the purpose of giving a strong flavor or relish. Condiments usually appear on the table and are intended for individual use by the diner.
- Something used to give delight to food, and to gratify the taste; a pungent and appetizing substance, as pepper or mustard; seasoning.
- A substance, such as a relish, vinegar, or spice, used to flavor or complement food or to add taste only.
- Seasoning added to flavour foods, such as salt, or herbs and spices such as mustard, ginger, curry, pepper, etc. Although some are relatively rich in nutrients, they are generally used in such small quantities that they make a negligible contribution to the diet

- A savory, piquant, spicy or salty accompaniment to food, such as a relish, sauce, mixture of spices and so on. Ketchup and mustard are two of the most popular condiments.
- Condiments are usually applied by the diner. Condiments are sometimes added prior to serving, for example a sandwich made with ketchup or mustard sauce. Some condiments are used during cooking to add flavor or texture to the food; barbecue sauce, teriyaki sauce, and soy sauce are examples.

Both spices and condiments contain essential oils, which provide the flavour and taste. They also stimulate digestion on account of their carminative properties. They are of little nutritive value. They are used whole, ground, paste or liquid from, mainly for flavouring and seasoning food. Most spices increase the shelf life of food, especially the dry varieties. Some are added to improve texture and some to introduce a palatable colour or odour.

Brief history of Spices

The utilization of spices known since the beginning of human civilization. In medieval times, the wordIndia conjured up a vision in the minds of foreigners as a land of maharajas, diamonds, fine textiles, ivory and of course, spices. The world still looks upon India as the real Home of Spices‘. The reason is not far to seek, as the quality of spices produced and exported from India has been and continues to be undisputedly the best. In ancient times, spices ranked with precious stones in the inventory of royal possessions and were monopolized by the few. They (spices) determined the wealth and policies of nations and also played an important role in ancient medicines. Besides, they also provided an incentive for the discovery of new waterways and new continents.

Centuries before the birth of Greece and Rome, sailing ships carried Indian perfumes, spices and textiles to Mesopotamia, Arabia and Egypt. It was the lure of these commodities that brought many sailors to the shores of India.

Long before the Christian era, the Greek merchants thronged the markets of south India, buying spices among other precious things. Epicurean Rome was spending a fortune on Indian spices, silks, brocades and cloth of gold. The Parthian wars are believed to have been fought by Rome largely to keep open the trade route to India. It is also said that there might have been no crusades and no expeditions to the East without the lure of Indian spices and her other famed products.

Today, when spices cost so little, it seems unbelievable that they were once a royal luxury and those men were willing to risk their lives in quest of them. It was in 1492 that Christopher Columbus discovered the New World. Five years later, tiny ships sailed southward from the port of Lisbon, Portugal, under the guidance of Captain Vasco da Gama. Like Columbus, Vasco da Gama too was searching for a new route to the spice lands of Asia. While Columbus failed to achieve that goal, da Gama succeeded and reached Calicut at the Malabar Coast of India. In a 2-year 38,623-km trip, he took his ships around the continent of Africa to India and back to Lisbon. Only 2 of the 4 ships could reach their home-port, bringing back a cargo of spices and other products worth 60 times the cost of the said expedition.

The spices of the East were valuable in da Gama‘s time, as they had been for centuries, because they could be used to stretch Europe‘s inadequate supply of food. During the Middle Ages, a pound of ginger was worth a sheep, and a pound of mace worth 3 sheep or half a cow pepper, the most valuable of all spices, was counted out in individual pepper-corns and a sack of pepper was said to be worth a man‘s life! Vasco da Gama‘s successful voyage intensified on international power struggle for control over the spice trade. For 3 centuries, the nations of Western Europe, i.e., Portugal, Spain, France, Holland and Great Britain fought bloody sea-was over the spice-producing colonies.

In a nutshell, the fascinating history of spices is a story of adventure, exploration, conquest and fierce naval rivalry.

The people of olden times used spices, as we do today, to accentuate or modify the flavours of their foods. Spices were also flavour disguisers, masking the taste of the tainted food that was still nutritious, but if unspiced would have been discarded. Some spices were also used for preserving foods like meat for a year or more without refrigeration! In the sixteenth century, cloves, for instance, were among the spices used to preserve food without refrigeration. Cloves contain a chemical called eugenol that inhibits the growth of bacteria. It is still used to preserve some modern foods like Virginia ham. Likewise, later mustard and ground mustard were also found to have preservative qualities. When spices were not available, people went hungry because they could not preserve their foods to carry them over to the winter. Thus, the economic importance of spices was known by the ancient civilization and their discovery of prime places was mentioned in the history.

Scope and Importance of spices

India, considered as the "Land of Spices" is one of the major spice producing and exporting country of the world, contributing about 20-25% of the world trade in spices. Besides, large quantities of spices are also considered within the country for seasoning and flavouring of foods and other products.

Out of 109 spices recognized by the International Organization for Standardization (ISO) world more than 60 spice crops are grown in India. India blessed with varied agro-climatic conditions, tropical, sub-tropical and temperate spices can be grown and having good scope for cultivation of majority of the spices.

There is a good export demand for Indian spices because of high quality with the maximum content of essential oil, oleoresin and active principles. In the present scenario, the food style or habit of people is changed to a greater extent, they are moving for "spicy food" because of good taste and aroma and love for fast food.

Spices and condiments find unique place in fast food preparations especially bakery products and confectionaries. Spices and condiments are high value and low volume crops, getting high income per unit area (pepper, cardamom, saffron, vanilla etc.).

These crops are having the characteristic of wider adoptability in different cropping systems. They can be cultivated as sole crop, inter crop, mixed crop and multi-storeyed cropping systems. These crops are both annual and perennial in nature; the products of these crops are the good source of raw material for ancillary industries. Thus, the industry provides more employment opportunities.

Among the spices, tree spices (cinnamon, clove, nutmeg and allspice) production is very limited (5000 MT) compared to the requirement of domestic demand (7000-8000 MT). There is a wide scope for enhancing area and production of these spices. Similarly the consumption and export of demand of seed spices are also increasing day by day both internal and outside the country. Therefore, there is a good scope for increasing area and production of these spices. Availability of high yielding varieties and advanced scientific package practices helps to the growers to realise higher income by cultivation of spices.

Karnataka is also able with favorable agro climatic conditions having costal, hilly, transitional and maidan regions, cultivating more than 17 spices and also having wider scope for cultivation of variety of spices.

Spices and its products are used as whole and powder form. Essential oils and oleoresins are widely used in seasoning of foods and imparting aroma, flavour and taste to the food products. These products are also finds unique place in cosmetic and pharmaceutical industries. Besides using spices, it is also used as colorant or dies in cotton textiles, tobacco industries, bakery

products, condiments, meat and fish products. Even now, it‘s usages in the preparation of Ayurvedic medicines is unbelievable. Value added products are great demand in food industries.

Role of spice crops in national economy

The world trade in spices had been, since the end of Second World War, recording steady increase both in terms of quantity and value. The growing increases in the standard of living of the people, the fast changing food habits and the preferences of exotic foods contributed substantially for the increase in the consumption of spices, the world over. The total world demand for spices exceeds then world's supply. There are about 109 spices in use all over the world and twenty countries actively engage in the production and export of one or more of them. Although India had enjoyed a monopoly in world's spice trade once upon a time, the position today is that no single country enjoys any monopoly position either in the production or export of spices.

India has a well-known reputation as a land of spices from time immemorial. Explorers and foreign invaders from Greece, Rome and other European countries were attracted mainly by the spices of India. Long before the Christian era, the Greek merchants thronged the markets of South India for buying spices. Once these spices were considered as luxury but today they have become an integral part of our daily diet. Indian spices travel throughout the world to flavour food and beverages and for use in packing, medicinal preparations, cosmetics and perfumery. India produces and exports almost all the spices in sizeable quantities. The total annual averageproduction of spices in India is estimated 2.49 million tons.

Indian export accounts for 30 to 40 per cent of the world trade and nearly 20-37 per cent of the foreign exchange is obtained through pepper, the 'Black Gold' among spices. Pepper 'The Kind of spices' is the largest foreign exchange earner and Indian pepper is also of the finest quality. Next to pepper, cardamom is the most important spice crop grown in India. Indian cardamom is well known throughout the world for its quality and high oil content. India accounts for more than 30 per cent of the world production. The production has to be stepped up to meet the increasing world demand. Countries such as Guatemala, Sri Lanka and Cambodia are the keen competitors for India in cardamom.

Apart from these two major spices, India produces tree spices like clove, nutmeg and cinnamon. Though tree spices have been in cultivation for more than 150 years, their production is not adequate to meet the internal demand. For instance, India is the second largest clove consuming country, with its major requirements met by imports from Indonesia. There is vast scope to expand the area under these spices at least to arrest the drain on foreign exchange.

India exports oil of pepper, cardamom, ginger, celery, cumin, cinnamon leaf and oleoresins of pepper, ginger, chillies, turmeric and fenugreek to West Germany, Japan, France, Australia, U.S.A, etc. These extractions of spices offer very good scope and a lucrative area for diversification and rapid expansion in export, if suitable modern techniques are adopted.

Another new and the latest trend noticed in the diversification of spices exports is in powder form, both in bulk and retail sale. Powders of chilies, turmeric, pepper etc. have started their way to foreign countries in appreciable quantities. With a view to study the problem relating to export trade in spices and also to take positive steps to augment exports, the Spices Export Promotion Council was established jointly by the Govt. of India and the Spice Trade in 1960. The objectives of the council are to support, protect, maintain, increase and promote exports in all spices which include undertaking of market surveys, sending trade delegations, appoint representatives in foreign countries conducting propaganda regularly within the country as well as abroad and investigations of complaints received from buyers, making recommendations to government and public bodies etc. To study the various problems relating to internal and external markets, quality control etc. the

council formed six different panels for pepper, cardamom, chillies, ginger, turmeric, curry powder and minor spices.

Cardamom is a plantation crop as per cardamom Act 1965 and as such comes under the preview of Ministry of Commerce, Govt. of India. The ministry established cardamom Board by an act of parliament on 14th April, 1996 to oversee research and development of small and large cardamom.

Area and Productionof Spices

Table: State wise Area and Production of Spices Crops

Sr. No.	States/Uts	2011-12		2012-13		2013-14	
		Area (in '000 Ha)	Production (in'000 MT)	Area (in '000 Ha)	Production (in'000 MT)	Area (in '000 Ha)	Production (in'000 MT)
1	Andaman Nicobar	1.651	2.984	1.74	3.57	1.68	3.22
2	Andhra Pradesh	292.819	1129.314	312.62	1187.68	169.36	775.82
3	Arunachal Pradesh	10.050	61.600	10.17	64.27	10.17	64.27
4	Assam	93.045	261.557	96.66	287.50	93.08	279.14
5	Bihar	13.010	12.540	13.01	12.54	13.01	12.54
6	Chhattisgarh	11.671	8.317	12.31	15.37	11.80	8.30
7	Goa	0.731	0.234	0.73	0.23	0.91	0.28
8	Gujarat	551.665	882.141	551.68	882.14	541.82	848.48
9	Haryana	12.798	61.685	16.13	82.82	16.13	82.82
10	Himachal Pradesh	4.766	19.259	7.30	10.26	8.43	14.16
11	Jammu & Kashmir	4.147	1.077	4.14	1.07	4.94	1.07
12	Jharkhand	0.00	0.00	0.00	0.00	0.00	0.00
13	Karnataka	265.117	502.461	213.75	369.85	191.79	333.83
14	Kerala	254.550	112.802	170.01	128.86	166.96	114.06
15	Madhya Pradesh	299.910	461.170	299.91	461.17	284.91	454.17
16	Maharashtra	116.520	106.470	120.76	109.04	120.76	109.04
17	Manipur	10.470	24.140	10.47	24.14	10.47	24.14
18	Meghalaya	16.842	74.816	16.85	74.81	17.50	83.88
19	Mizoram	20.649	114.982	22.47	59.62	22.47	59.62
20	Nagaland	9.765	39.166	9.77	39.16	9.77	39.16
21	Odisha	123.924	187.500	123.92	181.50	123.32	181.50
22	Puducherry	0.086	0.115	0.03	0.03	0.09	0.38
23	Punjab	18.370	68.210	18.37	68.21	19.13	70.92
24	Rajasthan	730.506	871.639	720.64	860.89	819.51	674.84
25	Sikkim	24.380	54.410	26.56	60.08	32.06	55.80
26	Tamil Nadu	157.331	426.381	124.39	279.61	166.00	554.52
27	Tripura	5.684	18.040	5.69	18.04	5.69	18.04
28	Uttar Pradesh	58.286	201.973	60.18	212.32	61.66	244.02
29	Uttarakhand	6.604	38.770	8.09	41.08	8.09	41.08
30	West Bengal	97.124	207.704	97.56	207.66	97.56	207.72
31	Telangana	0.00	0.00	0.00	0.00	134.18	551.47
	Total	3212.471	5951.458	3075.90	5743.52	3163.24	5908.29

Source: National Horticulture Bourd Web site http://www.nhb.gov.in/area%20_production.html

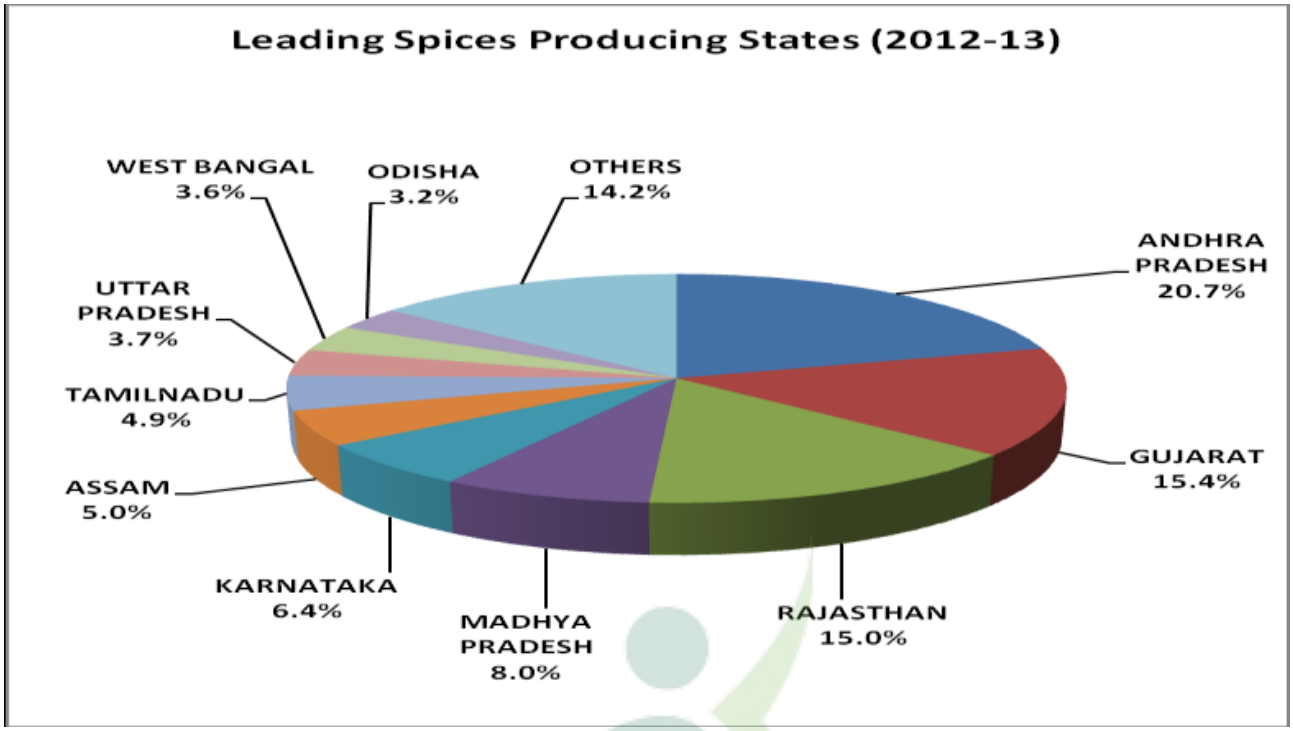

Table: Spices Crops wise Area and Production in India

Sr. No.	Crop	2011-12		2012-13		2013-14	
		Area (in '000 Ha)	Production (in'000 MT)	Area (in '000 Ha)	Production (in'000 MT)	Area (in '000 Ha)	Production (in'000 MT)
1	Pepper	200.279	40.622	124.60	52.61	123.81	50.87
2	Ginger	155.063	755.618	136.25	682.63	132.62	655.06
3	Chillies	804.792	1276.301	794.12	1304.38	774.87	1492.14
4	Turmeric	218.646	1166.843	194.23	941.09	232.67	1189.89
5	Garlic	242.491	1228.324	247.52	1259.27	230.59	1251.88
6	Cardamom	89.006	15.815	92.39	18.43	92.84	21.28
7	Coriander	557.870	532.947	543.20	523.88	447.13	313.65
8	Cumin	593.980	394.328	593.98	394.33	858.90	513.85
9	Fennel	99.554	142.949	99.61	142.95	54.16	70.12
10	Fenugreek	93.605	115.929	93.12	112.87	65.94	89.61
11	Ajwan	35.376	26.778	35.38	26.78	26.67	19.20
12	Dill / Poppy /Celery	33.470	32.642	33.47	32.64	33.47	32.64
13	Cinnamon /Tejpat	2.944	5.035	2.95	5.05	2.77	5.05
14	Nutmeg	17.485	12.574	17.49	12.62	18.90	12.78
15	Clove	2.387	1.105	2.38	1.10	2.06	1.07
16	Tamarind	58.428	202.574	58.11	201.82	58.59	188.13
17	Saffron / Vanilla	7.095	1.074	7.10	1.07	7.25	1.07
	Total	3212.71	5951.458	3075.90	5743.52	3163.24	5908.29

Source: National Horticulture Bourd Web site http://www.nhb.gov.in/area%20_production.html

Table: Production Share of Major Spices in India (2012-13)

Sr. No.	Crop	Production Share (in %)	Sr. No.	Crop	Production Share (in %)
1.	Pepper	**0.92**	9.	Fennel	2.49
2.	Ginger	11.89	10.	Fenugreek	1.97
3.	Chillies	22.71	11.	Ajwan	0.47
4.	Turmeric	16.91	12.	Cumin	6.87
5.	Garlic	21.93	13.	Nutmeg	0.22
6.	Cardamom	0.32	14.	Clove	0.02
7.	Coriander	9.12	15.	Tamarind	3.51
8.	Cinnamon /Tejpat	0.09	16.	Saffron / Dill / Poppy /Celery /Vanilla	0.59

Source: Indian Horticulture Database-2013

Some of the important spices of India are pepper, cardamom, chilli, ginger, turmeric, coriander, cumin, fennel, fenugreek, celery, saffron, tamarind and garlic. Other spices produced and exported in small quantities are aniseed, bishop's weed (ajawan), dill seed, poppy seed, *tejpat,* curry leaves, cinnamon, kokam and a few other culinary herbs. The tree spices like clove, nutmeg, mace, star-anise, allspice and some of the herbal spices like rosemary, thyme, marjoram, oregano, chive, parsley, sage, savory, tarragon and basil are produced in small quantities, which are mainly utilized in domestic purpose. Commercial cultivation has still not commenced in vanilla and paprika, but there is immense potential for their production and export.

Kerala retains the lead in black pepper production in the country, contributing 96% of area and 97% of production. The black pepper area in India increased from 0.8 lakh hectares in 1950-51 to 1.95 lakh hectares in 2009-10. Similarly, production increased from 20,500 tonnes to 51,200 tonnes from 2009-10 onwards, mainly due to the lucrative prices prevailing for black pepper in the domestic and international markets. The annual growth rates observed for area, production and productivity of black pepper for the last decade were 1.3, 3.3 and 2%, respectively. However, it is paradoxical to note that in spite of highly favourable climate, improved varieties and high-tech production technologies, the productivity of black pepper in the country is very low (300 kg/ha) compared to the other pepper producing countries.

Cardamom, the 'Queen of Spices' enjoys a premium preference in the international market and is relished for its distinct enriching properties. The data on area under cardamom cultivation in India reveal that there was not much fluctuation during the last four decades. The highest area of 1.0 lakh hectares was recorded during 1985-1986, which was reduced to 90,200 hectares in 2009-10. Cardamom production declined to as low as 3,500 tonnes in 1998-1999 and raise to 21,280tonnes in 2013-14. The record price of cardamom was realised during 2009-10, which was as high as Rs.1,200/kg.

India is the foremost producer and exporter of chillies. Among the various spices produced in the country, per capita consumption is the highest for chillies. Trends in area, production and productivity show a marked increase from 1950-51 to 2013-14. During 2013-14, the area under the crop was 7.75 lakh hectares with a production of 14.92 lakh tonnes. The price of chilli was Rs. 32.01/kg during 2000-01 which is slightly less than the average of the last three years (Rs. 45-60/kg).

Turmeric is a multipurpose crop valued for its colouring pigment, spicy flavour and medicinal properties. The area and production of turmeric in the country showed increasing trends during the last five decades. The highest area (2.33 lakh hectares), production (11.90 lakh tonnes)

and productivity (5,100 kg) was recorded in 2013-14. The annual growth rate is encouraging in the last five years. The price of turmeric had plummeted to around Rs.26/kg kg during 2000-01. The lucrative price of Rs.160/kg was recorded during 2013-14, which was considered to be highest price in the last decades.

Garlic is a major spice crop grown in Madhya Pradesh, Gujarat, Orissa and Rajasthan. The crop is grown over an area of 2.3 lakh hectares with a production of 12.52 lakh tonnes (2013-14). The price of garlic has raise to Rs. 80-100/kg during the current year from the average of Rs.40/kg for the last five years.

Ginger is one of the oldest known spices in the world and Indian ginger is highly valued in the global market because of its characteristic flavour. Being an annual crop, the area and production are highly influenced by price fluctuations. During 1970-71, the area under ginger was only 0.21 lakh hectares which went up to 0.77 lakh hectares in 1999-00 and 1.33 lakh hectares in 2013-14. Ginger prices have remained almost constant at Rs.35-40/kg during the last five years.

Nutmeg, cinnamon, clove, *tejpat,* tamarind and *Garcinia* are the important tree spices grown in India. The area under these crops is registering an upward trend mainly because of the attractive prices, both from domestic and international markets. *Garcinia* is a tree which is gaining importance due to the presence of an anti-obesity factor and pro-hydroxy citric acid in the fruit rind.

The area under nutmeg is 18900 hectares with an annual production of 12,780 tonnes; while for clove, the area and production are 2,060 hectares and 1,070 tonnes, respectively. Cinnamon occupies an area of 2,770 hectares with a production of 5,050 tonnesduring 2013-14.

The production of spices in the country has increased during the XII Five Year Plan to 59.08 lakhs tones during 2013-14.Among the spices grown in the country, seed spices account for 37% and 17% of the total area and production, respectively. Seed spices contribute to approximately 24% of export and 10% of the national income from spices. Out of the 17 seed spices produced in the country, coriander, cumin, fennel, fenugreek, dill seed, celery and poppy seeds are important. The area under these crops is around 8.55 lakhs hectares with an annual production of 5.01 lakh tonnes.The production and productivity of these crops increased mainly as a result of improve varieties and sound crop management practices.

Spices Export

The changed economic scenario order in the context of globalization and liberalization of world trade in agriculture has opened up new vistas of growth. The spices sector is one of the key areas in which India has an inherent strength to dominate the global markets. As a result of the recent WTO regime, quality competitiveness has emerged as the prime mover of international food marketing. The present dispensation, of course, widens the access to global markets, but at the same time raises many challenges for survival of the spice industry.

In India, spice exports have been consistently moving up during the last decade. The Spices Board under the Ministry of Commerce has the mandate for the export of spices from the country. Spices account for about 16% in quantity and 19% in value of the total horticultural exports from India. India's share of the world spices trade is estimated as 4050% by volume and 25% by value.

During 1999-00, Indian spices exports rose creating an all-time record in terms of value. Thus, for the last couple of years, India has been enjoying a commanding position in the global market. However, in 2000-01 the scenario changed due to the fall in the export of black pepper. According to the estimates of the Spices Board, Indian spice export during 2010-11 was estimated at 5,25,750 tonnes valued at Rs. 6,840 crores as against 5,027,50 tonnes valued Rs.5,560-50 crores in the previous year (2009-10), showing increasing trend of export earnings.

Indian pepper exports, which account for a major part of the global share, seems to be facing a stiff threat from the new entrants, especially Vietnam. During 2010-11 India exports18,850

tonnes with an value of Rs.383.18 crores which shows an slight declining trend compared to previous year (2009-10) 19,750 tonnes of pepper exported with an value of 31392 crores. The way to meet the challenge is to develop a market-oriented production strategy, that is, to increase productivity, encourage value additions and adopt organic cultivation.

With better production and the resultant decline in the price, Indian cardamom (small) export was increased by 70% in quantity and 77% in value. Export of large cardamom also increased by 36% in quantity and 63% in value.

Better production in the competing countries like China and Pakistan and the low volume of import by Bangladesh has resulted in the decline in export of chillies during 2000-01. During 2010-11 India exports 2.4 lakh tones of chillies earning foreign exchange of Rs.153.55 crores.

The export of ginger and turmeric also registered a slight increasing trend in both quantity and value. Seed spices account for 20% of the total foreign exchange earnings contributing to a volume of 13% of the total spice export. Among seed spices, the export of cumin during 2010-11 was 32,500 tones with an value of 39.59 crores. The export of value-added products like curry powder, mint products, oils and oleoresins has been steadily increasing during the past years and during 2010-11 India exported 15,250 tonnes of curry powder, 1,750 tonnes of mint products, 7,600 tonnes of oils and oleoresins worth of Rs.262 crores. Thus the spice industry has play an important role in enhancing the Indian economy by contributing sizeble foreign exchange.

Constraints faced in production

1. Lack of availability of quality planting materials as adequate infrastructure for large-scale production and distribution of quality planting materials of the released varieties.
2. Low productivity is due to existence of varieties of poor genetic potential with regard to yield and quality parameters.
3. Lack of development of advanced agro-techniques
4. Non adoption of recommended cultural practices.
5. Inadequate extension network for effective transfer of technology.
6. High fluctuations in prices of the commodities and the absence of a support price.

Uses of spices and condiments

Spices and condiments are used in various form and ways.

- Uses for making *chutaney* (garlic and chillies)
- Pickle making (green pepper, ginger, chillies)
- As preservatives (clove, black pepper, mustard seeds)
- Coloring matter for making curry powder (turmeric, chillies, coriander, cumin, ginger, black pepper, cinnamon).
- Essential oil for the use of soft drinks, perfumes, toilet soap (ginger, black pepper, celery, cardamom, nutmeg, vanilla)
- Oleoresin (obtained from black pepper, ginger, capsicums, turmeric, celery, methi, cardamom).
- Uses for pungency, flavour and aroma in meat processing, food industries etc.
- Cosmetics (turmeric, clove, methi, nutmeg).
- Most of the spices and condiments are used as an ingredient in medicine and drug preparations.
- Besides, many of them are good source of nutrients like vitamin A (carotene) from chillies, coriander, black pepper, clove;
- Thiamine from chillies, cumin, nutmeg, methi, mace, coriander.
- Riboflavin from chillies, cumin, coriander, methi, garlic, small cardamom etc.
- Vitamin C is available only in chillies and garlic but in traces in other spices and condiments.
- Majority of people are quite aware about various uses of spices and condiments as an economic and as in medicines.

- In fact, spices and condiments are so common even most of them are grown in kitchen gardens and in backyards.
- They are home remedies of several ailments.
- They are easy to grow, can be preserved for longer period, and are costly.
- At least, some of these can be used as 'first aid' in several disorders.

CLASSIFICATION OF SPICES AND CONDIMENTS

The spices can be classified in several ways based on

1. Based on plant parts used - leaves, flowers, barks, rhizomes, fruits, and seeds
2. Based on economic importance
3. Based on climatic requirement
4. Based on origin and flavor
5. Based on life cycle
6. Based on botanical relationship
7. Based on growth habit

I. Classification based on plant parts used

Spices can be classified depending on the parts of the plant that are to be used. Different plant parts like leaf, root, bulb, fruit, seed, etc. are used as spice.

a.	Seed	Cumin, black cumin, fenugreek, coriander, fennel, ajowan, poppy, aniseed and mustard
b.	Bulb	Onion, garlic, leek and shallot
c.	Bark	Cinnamon and cassia
d.	Fruit	Chilli, cardamom, allspice and kokam
e.	Leaf	Mint, curry leaf, bay leaf, chive, rosemary, savory Basil, marjoram and sage
f.	Rhizome	Turmeric, ginger, mango ginger and Aplinia
g.	Pod	Vanilla and tamarind
h.	Kernel	Nutmeg
i.	Floral part	Saffron, savory, caper and marjoram
j.	Bud	Clove and caper
k.	Latex	Asfotida
l.	Aril	Mace and anardana
m.	Berry	Black pepper, juniper and allspice
n.	Root	Angelica, horse radish
o.	Fruit	Tamarind and Garcinia

II. Classification based on economic importance

On the basis of economic importance of the spices grown in India they can be grouped into two *viz.*, major and minor spices.

i. Major spices:

The spices which contribute major share in the spice trade industry of the world are called major spices. The spices come under this group are small cardamom, black pepper, chilli, turmeric and ginger. These spices contribute about 75-90% of the total foreign exchange earned through spices.

ii. Minor spices:

Excluding all these five major spices, all other are called minor spices. Minor spices are further divided into five sub groups. They are mentioned hereunder:

a. Seed spices: Coriander, cumin, black cumin, fennel, aniseed, celery, poppy, etc.
b. Bulbous spices: Garlic, onion, leek and shallot
c. Aromatic spices: Clove, cinnamon, allspice, aniseed and nutmeg
d. Leafy spices: Curryleaf, mint, rosemary, bayleaf, and parsley.
e. Acidulant tree spices: Tamarind, kokam and anardana
iii. Major tree spices: Nutmeg, clove, cinnamon, tamarind, allspice, kokum, curry leaf.
iv. Minor tree spices: Bilimbi, carambola
v. Herbal spices (Herbs): Basil, marjoram, rosemary, sage, oregano, etc.
vi. Others (Miscellaneous): Saffron, asafoetida, etc.

III. Classification based on climate requirement of the crop

Depending on suitable climatic conditions like temperature, sunlight, humidity and air of a particular climatic zone, spices are grouped into three categories.

a. Tropical spices:

Spices of this category need high temperature, and abundant humidity. They are easily damaged by low temperature. Tropical spices are ginger, turmeric, black pepper, cinnamon, kokam, galangal, small cardamom and clove.

b. Subtropical spices:

Sub-tropical climate is found where three distinct seasons like winter, summer and monsoon are found. Low temperature occurs in winter and high temperature during summer. Most of the spices require relatively low temperature during their vegetative or early growth stage and high temperature in reproductive stage. The examples of sub-tropical spices grown in winter are cumin, fennel, coriander, fenugreek, onion and garlic. Subtropical spices grown during summer are turmeric and ginger.

c. Temperate spices:

Spices of this type can withstand low temperature and frosty weather but are damaged easily in hot weather. Examples of temperate spices are thymes, saffron, savoy, caraway seed and asfoetida.

IV. Classification based on origin and flavor

Depending on the origin and flavour content of the spices, they can be classified as follows:
a. Aromatic spices: Cardamon, aniseed, clery, cumin, coriander, fenugreek and cinnamon.
b. Pungent spices: Ginger, chilli, black pepper and mustard
c. Phenolic spices: Clove and allspice
d. Coloured spices: Turmeric, saffron and paprika

V. Classification based on life cycle

According to the requirement of season of growth, spices are grouped into following three classes:

a. Annual spices: Spices which complete their life cycle in one growing season are called annuals.
Example: coriander, cumin, fennel, fenugreek, ajowan and black cumin.
b. Biennial spices: It needs two growing seasons to complete the life cycle.
Example: onion and parsley.
c. Perennial spices: Perennial spices are those which live for more than two years.
Example: Black pepper, saffron, clove, nutmeg and cinnamon

VI. Classification based on botanical description

No.	Name	Botanical name	Family	Habit of growth	Parts used
1	Onion	*Alliuum cepa*	Alliaceae	Annual	Green leaves and bulbs
2	Garlic	*Alliuum sativum*	Alliaceae	Annual	Green leaves and bulbs
3	Cumin	*Cuminum cyminum*	Apiaceae	Annual	Fruit
4	Coriander	*Coriandrum sativum*	Apiaceae	Annual	Leaf and the seed
5	Aniseed	*Pimpinella anisum*	Apiaceae	Annual	Fruit
6	Black cumin	*Nigella sativa*	Apiaceae	Annual	Fruit
7	Fennel	*Foeniculum vulgare*	Apiaceae	Annual	Fruit
8	Mustard	*Brassica juncea, B. nigra*	Brassicaceae	Herb, Annual	Seed
9	Chilli	*Capsicum annum*	Solanaceae	Annual	Fruit
10	Cinnamon	*Cinna*momum *verum*	Lauraceae	Perennial Tree	Leaf and stem bark
11	Clove	*Euginia caryophylus*	Myrtaceae	Tree	Flower bud
12	Black pepper	*Piper nigrum*	Piparaceae	Perennial climber	Fruit
13	Cardamom	*Elettaria cardamomm*	Zingiberaeeae	Perennial	Fruit
14	Cardamom (Large)	*Amomum subulatum*	Zingiberaeeae	Perennial	Fruit
15	Turmeric	*Curcuma longa*	Zingiberaeeae	Perennial herb	Rhizome
16	Ginger	*Zingiber officinale*	Zingiberaeeae	Perennial herb	Rhizome
17	Curry leaf	*Murraya koenigi*	Rutaceae	Shrub	leaf .

VII. Classification based on their growth habit

a. Herbs: Ajowan, coriander. Cumin, tenet, fenugreek, chillies, parsley

b. Shrubs: Rosemary, Chillies (perennial chillies),Pomegranate

c. Trees: Nutmeg, clove, cinnamon, tamarind, Garcinia, Japanese pepper

d. Climbers: Black peopper, tailed pepper, vanilla

e. Perennial herbs (rhizomatous herbs): Ginger, turmeric, mango ginger, Japanese ginger, galanga, asafetida.

Essential Oils and Oleoresins of Spices

As raw spices do not provide uniformity in flavour, strength and colour, spice oils and oleoresins are used in flavour formulations. The spice oleoresins and oils score over the respective raw materials in their flavour concentration, solubility, stability, uniformity and hygienic quality and are hence preferred in modern food industries. Spice oils are volatile substances which are mostly terpenic in nature and are obtained by the steam or hydrodistillation methods. Oleoresins are obtained by organic solvent extraction of the powdered spices and they contain essential oils fraction, bite principles, colour and resinous matter.

Spices board

Spices Board was constituted as a statutory body on 26th February 1987 under section (3) of the Spices Board Act, 1986 (No. 10 of 1986) with the merger of the erstwhile Cardamom Board (1968) and Spices Export Promotion Council (1960). Spices Board is one of the five Commodity Boards functioning under the Ministry of Commerce & Industry. It is an autonomous body responsible for the export promotion of the scheduled spices and production development of some of them such as Cardamom.

The Board is headed by a Chairman with its head office at Kochi and is responsible for the development of cardamom industry and promoting the export of all the 52 spices listed in the spices Board Act, 1986.

Role of the Spices Board

(i) Develop, promote and regulate export of spices;
(ii) Grant certificate for export of spices and register brokers therefore;
(iii) Assist and encourage studies and research for processing and PH techniques.
(iv) Strive towards stabilization of prices of spices for export.
(v) Evolve quality standards and introduce certification of quality through "Quality Marking" for export.
(vi) license procedure to the manufacturers and exporters.
(vii) Market any spice, if it considers necessary, in the interest of promotion of export.
(viii) Provide warehousing facilities abroad for spices.
(ix) Collect statistics with regard to spices for compilation and publication.
(x) Import, with the approval of the Central Government, any spice for sale, and
(xii) Advise the Central Government on matters relating to import and export of spices.

Role of Board for Cardamom

(i) Promote co-operative efforts among growers of cardamom.
(ii) Provide financial or other assistance to farmers for agro-techniques and processing of cardamom.
(iii) Regulate the sale of cardamom and stabilization of prices of cardamom.
(iv) Provide training in cardamom testing and fixing grade standards of cardamom.
(v) license procedure for persons engaged in the business of cardamom.
(vi) Statistical works regarding cardamom industry.
(vii) Undertake, assist or encourage scientific, technological and economic research.

Export Promotion Councils (EPCS)

Presently, there are fourteen Export Promotion Councils under the administrative control of the Department of Commerce. These Councils are registered as non-profit organizations under the Companies Act/ Societies Registration Act. The Councils perform both advisory and executive functions. The role and functions of these Councils are guided by the Foreign Trade Policy, 2009-14. These Councils are also the registering authorities for exporters under the Foreign Trade Policy 2009-14.

Functions of the EPCs are

a) To provide commercially useful information and assistance to their members in developing and increasing their exports;
b) To offer professional advice to their members in areas such as technology upgradation, quality and design improvement, standards and specifications, product development, innovation, etc.;
c) To organize visits of delegations of its members abroad to explore overseas market opportunities;
d) To organize participation in trade fairs, exhibitions and buyer-seller meets in India and abroad;
e) To promote interaction between the exporting community and the Government both at the Central and State levels; and
f) To build a statistical base and provide data on the exports and imports of the country, exports and imports of their members, as well as other relevant international trade data.

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BLACK PEPPER

Scientific Name :*Piper nigrum* L.
Family : Piperaceae
English name : Black Pepper
Indian names : Kali Mirch (Hindi), Kare Menasu (Kannada), Kurumaluku, Nallamulaku (Malayalam), Maricha Ushana, Hopusha (Sanskrit), Milagu (Tamil), Miriyalu (Telugu).

Black pepper is admired as "king of spices" and "Block gold" is one of the oldest and the world's most important spices. Among all the spice crops, pepper which has the highest contribution to foreign exchange and trade turn over. Black pepper of commerce is the dried, matured and un- ripened fruit of *Piper nigrum*. The alkaloid piperine is considered to be the major constituent responsible for the biting taste of black pepper.

The other pungent alkaloids present in black pepper in smaller amounts, are chavicine, piperidine and piperetine. The characteristic aromatic odour of pepper is due to the presence of a volatile oil in the cells of the pericarp. On steam distillation, crushed black pepper yields 1.0-2.6% (upto 4.8%) of the volatile oil. Pepper is used for a variety of purposes. It is more frequently and regularly used than any other spice, as a condiment. It stimulates the digestive organs and thus produces an increased flow of saliva and gastric juices. It is used for seasoning many dishes and it imparts its characteristic blend of flavour and pungency to the cuisine. The ancient Aryans considered pepper as a powerful remedy for various disorders of the anatomical system and prescribed it as an effective cure for dyspepsia, malaria, delirium tremors, haemorrhoids, etc. The Egyptians used it for embalming.

The Asians are said to have used it as an aphrodisiac. However, its value as an essential preservative for meats and other perishable foods has been known for centuries. It is, therefore, largely used by meat packers and in canning, pickling, baking, confectionery and the preparation of beverages. It is also used as flavouring in culinary seasonings of universal use and an essential ingredient of numerous commercial foodstuffs.

Origin and distribution

Pepper is originated in the tropical evergreen forests of Western Ghats of India. It occurs wild in the hills of Assam and North Burma. The Malabar Cost of India was the centre of pepper trade from time immemorial. It is a perennial climbing plant, mostly cultivated as a mixed crop in coffee, citrus and arecanut plantations in Kerala and Karnataka. Besides India, pepper is now grown in Indonesia, Malaysia, Brazil, Madagascar, Sri Lanka, Vietnam, Thailand, China and the Federated State of Micronesia. In India it is grown mainly in Kerala, Karnataka, Tamilnadu and to a little extent in Goa, Orrissa, Assam and Andaman Islands. Kerala is the major state accounts for 95 % of countries area and production.

Area Production and Export

In India pepper is cultivated in an area of 1.95 lakh ha. with annual production of 51 metric tonnes. The average productivity is 300 kg/ha. Pepper accounts 1.3 % of the total area under spice crops (2009-10). Kerala has the largest share of pepper production accounting for 96%, followed by Karnataka (3.9%) and Tamil Nadu (0.1%). During 2010-11 India exported 18,1850 tonnes value at Rs.383.18 crores. India still maintains its position as the largest exporter of pepper and ground pepper to United States, Germany, Brazil, Indonesia and China.

Description of the Plant

Pepper is a large genus, with over 1,000 species, in the family *Piperaceae*. They are mostly herbaceous or woody climbers or shrubs distributed in the tropics of both hemispheres. The other economic species of the genus *Piper* are *P betle* L. (Betel vine) and *P methysticum* Forst (Kava). In

addition to *P nigrum* which now provides the true pepper of commerce, some of the species that have also been used as spices and as pepper substitutes are P *cubeba* (Cubeba or tailed pepper), *P longum* (Indian long pepper). *P retrofractum* (Java long pepper), etc. *Piper nigrum* is a climbing evergreen plant, growing to a height of 10 m or more. The vines branch horizontally from the nodes and do not attain much length. The pepper branches are dimorphic comprising:

(i) The orthotropic vegetative climbing branches with 5- 12 cm long internodes which give the framework of the plant, their stems are swollen at the nodes when young but become woody on aging; and

(ii) A plageotropic fruiting branch develops from the auxiliary bud present at each swollen node beside a leaf. The short adventitious roots produced at the nodes enable the plant to cling to the standard (climbing support). The leaves are alternate and simple, dark green and shiny above and pale green underneath. They are smooth and entire, broadly lanceolate but there is wide variation in leaf shape. The petioles are 2-5 cm long, and are grooved above.

1. Main stem:

Originate from a seed or from stem cutting, it climbs on a support with the half of aerial or adventitious

2. Runner shoots:

Are produced from the basal portion of the main stem, growing at rate angle to the main stem, usually restricted upto 50 cm from the ground.

3. Fruiting branches (plagiotropes):

Are produced from the modes of the main stem and they grow laterally more or less to the rate angle to main stem bears berries/spikes.

4. Top shoots (Orthotropes):

After a period of growth, top portion of the main stem attain busty appearance with short thicker inter nodes and profuse branching with large number of adventitious roots at the nodes. This portion of the main stem/shoot called top shoot or othotropes.

5. Hanging shoots (Geotropes):

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

Climate

Pepper is essentially a crop of the humid tropics and requires adequate rainfall and humidity. However, it thrives well even in the hot and humid climate of the foothills of the Western Ghats. It grows well at 500-1500 m elevation from the mean sea level. It requires a temperature of 10-40°C, below which the pollination and fruit set will be adversely affected. An optimum rainfall of 1250-2000 mm per annum distributed throughout the year is desirable. Though it is a shade-loving vine, too much of shade will affect flowering and fruiting. To avoid sun-scorching, it should be planted towards the eastern slopes avoiding the southwest sunlight.

Soil

Pepper thrives best on virgin soils rich in humus and naturally well drained; red lateritic soils or alluvial soils rich in humus are also highly suitable. Heavy clays and sandy soils should be avoided. In Kerala, pepper is also grown on the raised bunds of water-logged paddy fields. A pH range of 4.5 to 6.5 is ideal.

Varieties

The germplasm collection of black pepper at IISR is 2,776 (2,492 indigenous, 5 exotic and 279 wild). In India, out of about 100 varieties which are under cultivation, only ten have assumed commercial importance. The distinguishing characters of some of the important varieties are as follows.

Distinct varieties and forms are known to exist since a long time in South India. In the west coast of India many varieties with distinct qualities are known by their local names. Some of the common cultivated forms are as under.

I. Grown in Malabar & South Kanara region are

(1) Kalluvally , (2) Balankotta, (3) Cheriakody, (4) Uthirankotta, (5) Karimkotta

II. Grown in Maland area in Karnataka.

(1) Warkala Marata (2) Karimarata (3) Arasilamarata

(4) Doddagya (5) Malligesara (6) Tattisara.

III. Grown in Travancore region

(1) Karimunda (2) Veluthanamban (3) Cherriyakaniyakadan

(4) Kuthiravally (5) Chola (6) Chumala (7) Kumbhakodi

IV. Recently a nos. of improved cvs. have been evolved & released for cultivation.

Hybrids Cultivars are Panniyur -1, 2, 3, 4, 5, 6 & 7 released by Pepper Research Station, Panniyur KAU, (Kerala) and Sreekara, Subhakara, Panchami, Pournami are recently released varieties from IISR – Calicut, (Kerala).

Improved varieties of black pepper and their salient features

Variety/hybrid	Average yield (kg/ha)	Oleoresin (%)	Piperine (%)	Essential oil (%)
1	2	3	4	5
Panniyur 1: Suited to all regions. Not suited to heavily shaded areas	1,242.0	11.8	5.3	3.5
Panniyur 2: Shade tolerant	2,570.0	10.9	6.6	3.4
Panniyur 3: Late-maturing, suited to all pepper-growing regions	1,953.0	12.7	5.2	3.1
Panniyur 4: Performs well under a variety of conditions. Stable yielder	1,277.0	9.2	4.4	2.1
Panniyur 5: Tolerant to nursery diseases and shade	1,098.0	12.33	5.5	3.8
Subhakara: Suited to all pepper- growing regions	2,352.0	12.40	3.4	6.0
Sreekara: Suited to all pepper- growing regions	2,677.0	13.0	5.1	7.0
Panchami: Late-maturing, suited to all pepper-growing regions	2,828.0	12.5	4.7	3.4
Pournami: Tolerant to root-knot nematode	2,333.0	13.8	4.1	3.4
PLD 2: Suited to Thiruvananthapuram and Quilon districts of Kerala	-	-	-	-

Cheriyakaniyakkadan

The leaves are small and elliptic; the spikes are of medium length, closely set with medium-sized dark-green fruits. It is a popular type and bears regularly, the yield is heavy (42% dried pepper) and of high quality, it is wilt resistant and popular in north and central Travancore (Kerala).

Cheriakodi

The leaves are narrow and dark green; the spikes are short, with dark or pale-green fruits, which are the smallest among all the types. The plant is a dwarf and sturdy type, bearing in alternate years, and of a high quality. It yields 38% dried pepper and is popular in north Travancore and north Malabar (Kerala).

Daddagya

The leaves are broad and the spikes are long, and curved. The fruits are large among Mysore types. It is a uniform yielder, esteemed for making white pepper; it yields 38% dried pepper. It is popular in North Kanara (Karnataka).

Kalluvally

It is a promising cultivar of north Kerala, being a hardy and regular yielder. It is a regular bearer and reportedly tolerant to water stress and diseases. It is moderately tolerant to *Ph* ytophthora wilt. Though it is a very promising cultivar.

Kaniakkadan

The name Kaniakkadan appears to have been derived from Kaniakkar, a tribal sect inhabitating the hilly Western Ghat areas of the present day ldukki district. There are four different Kaniakkadan types. These are Cheriyakaniyakkadan, Valiakaniakkadan, Karutha Kaniakkadan and Valutha Kaniakkadan, of which the first two are more important.

Cheriyakaniyakkadan

It is a popular cultivar of the eastern parts of Kottayam and QuiIon districts. It is also commonly found in many areas of north Kerala. It is a bisexual type, with small elliptical leaves, medium-long spikes and medium-sized berries.

Arakkulamunda

This is a moderately good and regular bearer from the central area of Kerala. It derives its name from a village Arakkulam in the Thodupuzha taluk of Idukki district. It is commonly found in the settlement areas of north Kerala. It yields regularly and comes to maturity earlier than most other cultivars. The spikes are medium-long and the berries are bold and heavy. This cultivar gives 9.8% oleoresin, 4.4% piperine and 4.7% essential oil.

Balan cotta

This cultivar is confined to north Kerala and grows very vigorously. It has the largest leaves among all the Kerala cultivars. The vines are large, growing to the top of the large supporting trees like mango and jackfruit. The spikes are medium long to long, the setting moderately good, and the berries are bold and pale-green. The variety is early to medium in duration, the berries give about 30% driage. It gives 9.3% oleoresin, 5.1% essential oil and 4.2% piperine.

Karimcotta

The leaves are large, dark green and the spikes are short and curved with closely-set, large, dark-green berries. It is a hardy, regular bearer and a good yielder. It yields 42% dried pepper. It is popular in the north Travancore and north Malabar areas of Kerala.

Karimunda

The name Karimunda might have come from the bluish-black tender shoots and dark-green leaves and berries. It is the most popular cultivar grown throughout Kerala. The cultivar is bisexual and is characterised by small more or less oval leaves and short to medium-long, closely-set spikes. The spikes are 4 to 10 cm long and even more in certain cases, with a mean length of around 6.5

cm. It is a prolific and regular bearer, having medium-sized berries of good driage (35%) and yields good quality pepper. This cultivar has about 11% oleoresin, 4.4% piperine and 4.0% essential oil content. Its flowering time is in May-June, coinciding with the monsoon. The irrigated plants flower almost continuously. This cultivar is of medium maturity, and is suitable for intercropping and also for high density monocropping.

Kottanadan

It is the most popular pepper cultivar in South Kerala. This is a vigorous growing bisexual variety with large, broad, ovate leaves, long spikes, high fruit set and medium-sized berries. The cultivar is a high and regular yielder. Studies have shown that Kottanadan has the highest oleoresin content (17.8%). It has a high piperine content too (6.6%), though the volatile oil is comparatively less (2.5% to 4.2%). It gives about 37% driage and produces high quality, heavy pepper. In the Wynad area, Kottanadan is grown as Aimpiriyan, the name being derived from the fact that berries are arranged in 5 distinct rows on the spike. In south Kerala, it flowers by April-May and is ready for harvest by January. In Wynad, it matures late and comes to harvest only by April. Kumbhakodi, a cultivar grown in certain areas of Quilon, seems to be a variant of Kottanadan/Aimpiriyan.

Kuthiravally

A south Kerala type, now found in many pepper-growing areas throughout Kerala, Kuthiravally is a moderately high yielder, but an alternate bearer and the flowers are bisexual. The berries are medium-large, having high driage (over 39%). It yields about 15% oleoresin, 6.0% piperine and 4.5% essential oil. Kuthiravally thus produces high quality pepper.

A cultivar called Thommankodi, grown in certain areas in eastern parts of Calicut (Koodaathai, Anakkampoyil areas), seems to be a variant of Kuthiravally. In Thommankodi, the spikes are slightly shorter and the berry filling somewhat better than those of Kuthiravally. A quality analysis of this cultivar has not been carried out.

Aranavalan, a cultivar found in the Malayatoor-Kaladi areas, also seems to be a variant of Kuthiravally.

Malligesara

This is the common cultivar of North Kanara district of Karnataka. In the Malnad areas of North Kanara, this is usually intercropped with arecanut. Two types of Malligesara are known Karimalligesara and Bilimalligesara, which can be differentiated based on the anthcyanin colouration of the emerging shoots. In Karimalligesara it is purple- white and in Bilimalligesara it is pale-green. It is a moderate yielder, having medium-large leaves and spikes.

Narayakkodi

This is another central Kerala cultivar from the KottayamChampakkara-Mallappally tract, but is now found in many settlement areas throughout Kerala. It is a regular average yielder, having high driage (37.5%). It gives 11% oleoresin, 5.4% piperine and 4.0% essential oil. The farmers in central Kerala are of the opinion that `Narayakkodil has a longer life span than `Karimundal and is also much less affected by diseases. Studies conducted in the Central Plantation Crops Research Institute, Regional Station, Calicut, have shown that Narayakkodi is more tolerant to foot-rot caused by *Phytophthora* than most other cultivars. The following are some of the improved varieties and hybrids released from the Pepper Research Station, Panniyur, Taliparamba, Cananore district, Kerala and Indian Institute of Spice Research (IIS,Calicut).

Cultivation

Propagation

Pepper can be propagated by seeds as well as by vegetative means.

Propagation by seeds

The fully ripe berries are collected, soaked in water overnight and later rubbed with a paste

of cow dung. The treated seeds are sown in the nursery. The seeds are viable up to 20 days after the harvest. They germinate within a month in the nursery beds and will be ready for transplanting within 45 days. In India, transplanting is done in July- August. The seedling progenies show a lot of variation, since pepper is a cross-pollinated crop. They take 7-8 years to come to the first bearing.

Propagation by Vegetative methods

Selection of Mother Vine

The mother plants selected for the preparation of cuttings should possess the desirable attributes: such as regular and high yielding, healthy free from pests and diseases and preferably 5-12 years of age.

Conventional method

Mother plants selected for collecting cuttings should be marked during October-November. The runner shoots from these vines are kept coiled on wooden pegs fixed at the base of vines to prevent shoots from coming in contact with soil. The runner shoots are separated during February-March and 2-3 nodal cuttings of 20 cm length are made. These are planted either in nursery beds or polythene bags filled with potting mixture (made of soil, sand and farmyard manure in 1:1:1 ratio) after trimming the leaves.

Dipping the lower cut end in IBA 1000 ppm solution for 45 seconds will substantially increase rooting. Sufficient holes are to be provided at the base of polythene bags to ensure good drainage. Three node cuttings should be planted by keeping one node below the soil. The cuttings after planting should be kept under shade. Light irrigation is to be provided daily to maintain a humid and cool atmosphere around the cuttings. The cuttings will strike roots and become ready for planting in May-June when 4-5 leaves are produced.

Rapid multiplication method:

The modified rapid multiplication technique developed by IISR, Calicut is adopted for quick multiplication of rooted cuttings. This method originally developed from Sri Lanka. A suitable area having good drainage is selected and levelled. Overhead shade is provided by using 50 % shade net, Coconut leaves can also be used for roofing. Trenches of 30 cm width, 45 cm dept and of convenient length are taken and filled with soil, sand and farmyard manure (1:1:1). Bamboos of 8-10 cm diameter are selected and cut into 1.25-1.50 m long pieces and split into halves keeping the septa intact. Coal tar is smeared to prolong the life of bamboo splits. The bamboo splits are arranged at an angle of 45o alternatively either side on straight wooden poles or strong supports fixed on small supports from ground and tied to each other with coir rope at the free end. Rooted cuttings are planted in the trench, one of each bamboo split. As the cuttings start growing, the bamboo splits are filled with rooting mixture composed of farmyard manure, coir dust and sand in equal proportions. Each tender node is tied carefully to the bamboo using banana fibre, so that every node is in contact with the rooting medium. For rapid growth, daily irrigation through rose can is essential. Nutrient solution consisting of urea (1 kg), super phosphate (0.75 kg), muriate of potash (0.5 kg) and magnesium sulphate (0.25 kg) in 250 liter of water can be applied as foliar spray for good growth. Alternatively, spraying the vines with cow dung solution 0.1 % once ina month also encourages plant growth. When the vines reach the top of the bamboo, the tip is nipped off and the vine is crushed at the base of 3rd or 4th node from the ground, to activate the buds. After 7-10 days, the vine is cut at the crushed point and removed from the bamboo with the roots intact and with the adhering soil.

The vine is cut into single nodded pieces and each cutting is planted in a polythene bag filled with potting mixture of soil, sand and farmyard manure (1:1:1) or mixture with solarised soil fortified with bio-control agents or vermicompost. After planting in the bamboo, the first harvest of cuttings can be done after 3-3 ½ months and the subsequent harvest at every 2-2 ½ months. Each

rooted vine can give about 10 cuttings in one harvest and about 40 cuttings will be obtained in a year. A shed of 6 m x 24 m would accommodate 600 bamboo splits. On an average 20,000 cuttings can be produced annually by this method. The method is thus advantageous for producing a large number of rooted cuttings within a short period, throughout the year. The cuttings are also robust due to the abundance of roots leading to more than 90 % establishment in the field.

Serpentine method

This is the best propagation technique for black pepper. Three node cuttings planted in polythene bags are kept in a corner of the nursery. When the plant develops two leaves they are trailed horizontally in polythene bags containing potting mixture kept below each tender node. Each node should be pressed into the mixture in polythene bags with V shaped midribs of coconut leaves. As new shoots arise, these are to be trailed horizontally in polythene bags containing potting mixture. Once 20 nodes get rooted, the first 10 polythene bags with the rooted nodes should be separated by cutting at the inter nodes. The intermodalstub should be pushed back into the potting mixture. These stubs also produce a secondary root system. Daily irrigation is to be given using a rose can. After 3 months these cuttings are ready for planting in the field. On an average, 60 cuttings can be obtained in a year by this method from each mother cutting. The serpentine method is simple, less costly quick and can be adopted by small and marginal farmers. The recovery percentage is higher compared to rapid multiplication technique.

Pit Method

A pit of 2 m x 1 m x 0.5 m dimension is dug in a cool, shaded area. Single node cuttings 8-10 cm long and their leaf intact, taken from runner shoots of field grown vines are planted in polythene bags of 25 cm x 15 cm (200 gauge) size. Sufficient drainage holes are to be provided at the bottom of the bag. Soil, sand and farmyard manure in equal proportion (1:1:1) are mixed and used for filling the bag. The single nodes are to be planted in the bags in such a way that leaf axil rests above the potting mixture. The bags with the planted single nodes should be arranged in the pit. Approximately 150 bags can be kept in a pit. After keeping the bags in the pit, the pit should be covered with a polythene sheet. This sheet may be secured in position by placing stones or weights on the corners. The cuttings should be watered at least five times a day with a rose can. After two to three weeks of planting, the cuttings will start producing roots. After initiation of rooting, watering may be reduced to three to four times a day. After 1 month, shoots start emerging from the leaf axil. At this stage it is advisable to keep the pit open for about 1 hour per day so that the cutting will not suffer from any shock when they are taken out of the pit. Two months after planting, the cuttings can be taken from the pit and kept in a shaded place and watered twice a day.

These cuttings will be ready for field planting after about another two and a half months. By this method, 80-85% success can be obtained. This method is simple, less costly and quick. The cuttings are ready to be planted in the filed after about 4-4 ½ months as compared to 6 months in bamboo method. This method is suited to small and marginal farmers. Saving of planting material is also possible since single nodes are used instead of three nodes in the conventional method.

Micro-propagation

Micro-propagation of black pepper in vitro, using shoot explants both from mature and juvenile plants were standardized at the Indian Institute of Spices Research (IISR), Calicut. The multiplication rate is around six shoots per culture in 90 days. The protocols for plant regeneration were also standardized and the plants were successfully micro-propagated from the callus cultures derived both from leaf and stem explants Vegetative propagation by grafting Single-node cuttings could be successfully grafted, either by means of side grafting or inarching. Varieties like Uthirankotta can be successfully top worked with bisexual types and made productive.

Establishment of plantations

Selection of site

The site selected for cultivation of pepper should be cleared with shrubbery and wild growth. When it is grown in slopes, the slopes facing south should be avoided and the lower of half of the northern and north-eastern slopes preferred for planting so that the vine are not subjected to the scorching effect of the southern sun during summer. In slopes, suitable soil conservation measures are to be adopted.

Preparation of land and planting standards

With the receipt of the first rain in May-June, primary stem cuttings of Erythina sp. (Murukku) or Garuga pinnata (kilinjil) or Grevillea robusta (silver oak) are planted in pits of 50 cm x 50 cm x 50 cm size filled with cow dung and top soil, at a spacing of 2.5-3 x 2.5-3 m which would accommodate about 1100-1600 ppm standards per hectare. Seedlings of Alianthus malabarica (Matti) can also be planted and the black pepper vines can be trailed on it after 3 years when they attin sufficient height. Whenever E. Indica is used as standard, application of phorate10 G@ 30 g may be done twice a year (May/June and September/October) to control nematodes and stem and root borer. When *E. Indica* and *G. Pinnata* are used, the primary stems are cut in March / April and staked in shade in groups. The stacked stems start sprouting in May. The stems are planted in the edge of the pits dug for planting black pepper vines.

When pepper is grown as a mixed crop in coffee and coconut plantations or areca gardens, there is no need to plant standards or shade trees. The coconut or areca trees themselves provide shade and serve as standards. While planting, groups of 3 to 4 rooted cuttings are planted per standard.

Usually the planting of vines is done during June-July in pits of 50 cm3, dug on the northern side of the standard 60-120 cm away from the standard. The cuttings are planted with two nodes below the ground level. The pepper vine grows rapidly and after one year reaches a height of 2 m.

As the vines grow they have to be tied to the standards at an interval of 30 cm. Also, the vines are brought down to ground level after a year and a half. They are cut and buried in the ground surrounding the standard. This helps in putting forth more shoots and good root systems.

Planting

Pits of 50 cm3 at a distance of 30 cm away from the base, on the northern side of supporting tree are taken with the onset of monsoon. The pits are filled with a mixture of top soil, farmyard manure @ 5 kg/pit and 150 g rock phosphate. Neem cake @ 1 kg and Trichoderma harzianum @ 50 g also may be mixed with the mixture at the time of planting. With the onset of monsoon, 2-3 rooted cuttings of black pepper are planted individually in the pits on the northern side of each standard. At least one node of the cutting should be kept below the soil for better anchorage.

Cultural Practices

Training and Pruning

As the planted cuttings grow the shoots are trained by tying to the standards as often as required. Train the vine all-round the standards and allow to grow 68 meters. Then prune the top shoots. Pruning is not regularly followed in India, it is done mainly in young vine when they are about 6 months old. Terminal shoot is pruned back to 3 to 4 nodes from the ground, terminal shoots are then selected and trained on support. Pruning of hanging shoots dead and damaged shoots facilitates for better aeration and enhance the productivity of the plant. When it is grown with coconut plantations or areca gardens, there is no need to plant standards or shade trees.

Shade Management

Pepper is a shade loving plant, excess shade is detrimental since it affects the physiological activities of the plant. It requires 50 % shade or lesser than this for better growth and production.

Pepper is usually tried on living standards, which also served as shade trees. In coffee plantation shade tree are used as standards for pepper. In order to maintain 50 % of shade excess and unwanted branches are to be removed every year prior to commencement of monsoon April-May. Shade regulation helps for better penetration of lights during monsoon. The lopped branches putfourth new growth and providing shade during the commencement of summer period. Thus, lopping of branches of shade trees is essential to regulate shade or sun light suit to the crop.

Liming

Pepper is cultivated in heavy rain fall areas of hilly region, top soil along with nutrients or eroded as a result soils are acidic. Before application of fertilizers soil ph as to be corrected by adding line based on the soil test results. However, every two years once 2 to 3 tonnes of lime per hecters or 500 g per vine is recommended and this as to be applied during April-May. Agricultural line and dolomite line are commonly used liming materials to correct the soil acidity.

Manures and Fertilizers

The dose of manures and fertilizers to be applied per unit area varies according to the soil fertility. Manuring for pepper vines is to be done in basins in a semicircular band on the northern side of the standard around the plants, 10-15 cm deep and 50-75 cm radius, depending upon the growth of the plants. Cattle manure/compost/ green leaves should be applied at the onset of the Southwest monsoon. It is desirable to apply lime at the rate of 500 g per vine in April-May in alternate years.

Intercultivation

During the first year, a thorough digging is given once during August- September and again in October-November around the standard and the vines to remove the weeds. Mulching is very essential where pepper is grown with minimum shade, to conserve moisture, using banana trash, dried grass and other substances. Cover crops like *Calapogonium mucanoides, pureria phaseoloides, Mimosa invisa* can be sown during April-May and during October- November and they are cut and ploughed into the soil when they flower. Sawdust, areca husk and straw can also be used for mulching.

Weeding

Regular weeding is essential to keep the basin clean to avoid competition of weeds for moisture and nutrients. The three weeding are done during May-August and November manually without disturbing the roots. Gramoxoane, weedicide at the rate of 600-1200 ml per ha. can be used to arrest the weed growth.

Use of growth regulators

Spike shedding disorder is observed in pepper as a result 10 to 40 % of yield loss is recorded to overcome this problem apart from application of major and micro nutrients and control of diseases and pests, application of IAA (50 ppm), or planofix (50 ppm) and 2, 4-D (5 ppm) is recommended to control the spike shedding disorder.

Harvesting and yield

Pepper commences bearing third year after planting. Flowering and harvesting depend on climatic factors, the most important being rainfall. In India, pepper plants start flowering during May-June with onset of south west monsoon and harvesting is usually done in Dec.-January. At higher altitudes, the fruit growth and maturity get delayed. Generally harvesting is done when one or two berries in a few spikes turn orange or red. Care should be taken to harvest only mature spikes. Harvesting is done using single pole ladder kept leaned on to the support tree. Harvested spikes are collected in clean sacs or bags tied at back of worker. Harvested spikes are spread on a clean floor and threshed manually by trampling with legs or by using mechanical thresher. Manual

threshing is more common in India. The harvested spikes are piled up in a heap to initiate browning and then threshed. It makes threshing' easy and also gives good colour to finished product.

The yield varies widely in different pepper producing areas depending upon elevation, temperature, distribution of rainfall, soil fertility, cultural practices, type or variety and age of the vine. In India, the yield varies from 300 to 1000 kg/ha.

Processing

Black pepper

Black pepper of commence is produced from whole, ripe but fully developed berries. After threshing, they are spread on suitable drying floor for sun drying. Berries are raked to ensure uniform colour and to avoid mould development. Drying takes about 3-5 days by which time moisture content will be brought down to 10-12 %. The dried berries are garbled, graded and packed in double lined gunny bags. Blanching berries in boiling water for one minute prior to drying accelerates browning process as well as rate of drying. It also gives a uniform lustrous black colour to finished product and prevents mouldiness of berries. But prolonged blanching should be avoided, since it can deactivate enzymes responsible for browning process. The black colour that pepper acquires on drying is due to oxidation of colourless phenolic compounds present in skin. Dry recovery varies from 29 to 38 % among cultivars. Solar driers and mechanical driers are now available for drying pepper.

White pepper

White pepper is prepared from ripe berries or by decorticating black pepper. Bright red berries after harvest are detached from stalk and packed in gunny bags. Bags are allowed to soak in slow running water for about one week during which bacterial rotting occurs and pericarp gets loosened. Then the berries are trampled under feet to remove any adhering pericarp, washed in water and then sun dried to reduce moisture content to 10-12 % and to achieve a cream or white colour. White pepper is garbled, sorted and packed in gunny bags. Approximately 25 kg white pepper is obtained from 100 kg ripe berries. Central Food Technology Research Institute, Mysore, India improved the method in which fully mature but unripe berries are harvested and boiled in water for 10-15 minutes to soften the pericarp. After cooling, skin is rubbed off either manually or mechanically, washed and sun dried to obtain white pepper. Since no retting operation is involved, product will be free from any unpleasant odour. But white pepper produced by this method gives pepper powder of light green colour due to gelatinisation of starch in contrast to pure white powder obtained by traditional method.

Decorticated black pepper

This is a form of white pepper produced by mechanical decortication of outer skin of black pepper. Appearance of decorticated kernel is inferior to traditionally prepared white pepper, but is satisfactory when ground. Also the milling operation requires considerable skill to avoid excessive volatile oil loss.

Pepper oil

Black pepper is crushed to coarse powder and steam distilled to obtain 2.5 to 3.5 % colourless to pale green essential oil which becomes viscous on ageing. It is used in erfumery and in flavouring. Oil can also be distilled from white pepper but high price of white pepper and low oil yield do not favour its commercial production.

Pepper oleoresin

Extraction of black pepper with organic solvents like acetone, ethanol or dichloro ethane provides 10-13 % oleoresin possessing the odour, flavour and pungent principles of spice. Piperine content of oleoresin is 35 to 50 %. One kilogram of oleoresin when dispersed in an inert base can replace 15 to 20 kg of spice for flavouring purpose.

Garbling and grading

Before packing, dried pepper is cleaned to get rid of extraneous natters like dirt, grit, stones, stalks, leaves etc. and berries are graded according to size or density. In India, generally garbling and grading are done at exporters premises. Garbling machines remove dust, chaff and grade pepper according to densities. Manual cleaning is also done by hand picking the contaminants such as plant debris and other extraneous matter. Good garbled pepper should have a bulk density of 500-600 gram/liter. Light berries should be less than le % and pin heads (unfertilized) less than 4 %. Malabar Garbled (MG), Malabar Ungarbled (MUG), Tellichery Garbled Black Pepper Special Extra Bold (TGSEB), Tellicherry Garbled Extra Bold (TGEB), Garbled Light Pepper (GL) and Pin Heads (PH) are the important grades of black pepper.

Standard specifications for pepper

The Indian Government, through the Ministry of Agriculture and Food, has prescribed the obligatory grading and standardization of agriculture products under the label "AGMARK". This specifies limits for extraneous matter, light berries and moisture content. They provide a compulsory quality control and pre-shipment inspection apart from meeting the requirements of importing countries. For export, the American Spice Trade Association standards are generally followed adulterants like phellandrene, dipentene and caryophyllene, which are also natural components of the oil itself.

Products of Black pepper

Pepper oleoresin

It is prepared by the solvent extraction of ground pepper. The production process uses a number of equipments like precleaners, pulverizers, extractors and solvent recovery units. Besides, for quality control measures, instruments like gas chromatography and ultraviolet spectrophotometer are used. The oleoresin of pepper can be prepared based on the customer's quality requirement.

Piperine

The alkaloid piperine (3-6%) is the major constituent responsible for the biting taste of black pepper. The other pungent alkaloids are chovicine and peiperidine.

Green pepper in brine

Bottled green pepper has great demand in non-traditional areas. The green colour is maintained under the high salinity of the steeping liquid. The minimum salt level should be 12%. The addition of a small amount of citric acid prevents the discolouration due to phenols.

Dehydrated green pepper

Keeping the freshly harvested, despiked pepper in boiling water for over 10 minutes deactivates the bleaching enzyme. Treatment with sulphur dioxide reduces the chances of darkening. As sun-drying destroys chlorophyll and the green colour, to make dehydrated green pepper, drying should be done in hot air or in a microwave oven.

Frozen green pepper

This is prepared using blast freezers. Such peppers, on thawing, are almost equivalent to the fresh material. Other products like spice essences and emulsion, spice decoctions, encapsulated spices, fat-based spices, etc., are also prepared from black pepper.

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TURMERIC

Scientific Name: *Curcuma longa*L.
Family : Zingiberaceae
Origin : India
Plant part used : Rhizomes

Turmeric is known as the "golden spice" as well as the "spice of life". It is an erect, strongly tillering, herbaceous plant. *Curcuma domestica* Val., belonging to the family Zingiberaceae, is the plant from which the turmeric of commerce (dried rhizomes) is obtained. Although *C. domestica* is the correct botanical name for turmeric, *C. longa* is sometimes used in literature to describe the finger rhizome and*C. rotunda* for the bulbous central rhizomes.

Uses

- Turmeric mainly used as a flavoring and coloring agent in food industries. Turmeric is used as a condiment, dye, drug and cosmetic in addition to its use in religious ceremonies.
- It has a calorific value or food energy of 390 calories/100 g. The colouring principle content in turmeric is curcumin.
- Turmeric is an important spice among rice-eating people. Curry powder usually contains about 24% of turmeric powder, with other usual ingredients like coriander, cumin, cardamoms, fenugreek, chillies, ginger, pepper and dill seeds, etc.
- In addition to its use as a spice, it has other uses too. Turmeric is a natural source of yellow dye used for dying cotton, silk or wool without a mordant.
- Curcumin is highly aromatic with a musky odour and a pungent bitter taste. When it comes into contact with alkali it turns red and is called 'Kum kum'.
- Turmeric powder and water are used as cosmetics. Turmeric is considered a carminative, tonic, blood-purifier, vermicide and an antiseptic.
- It is used in folk medicine for intestinal disorders, worms, anaemia, measles, asthma, sore throat, cough and cold, diabetes, sprains, skin disorders, etc., both externally and internally.
- It is used as a colouring matter in the pharmacy, confectionery and the food industry. Yellow turmeric paper can be used as a test for alkalinity, which turns it brown.
- Turmeric oil and oleoresin are also used to impart flavour in food and perfume industries. The essential oil of turmeric is antiseptic. It is used in treating gall stones and gall complaints. The anti-microbial properties of essential oil from turmeric are reported against pathogenic bacteria and fungi.

Origin and distribution

India or China or the Indo-Malayan region is the home of turmeric. The crop has now become widely distributed throughout the tropics, but its cultivation as a spice is largely confined to India, Sri Lanka, China, Pakistan, Indonesia, Malaysa, Thailand, Philippines, Japan, Africa, Central America, Haiti, Jamaica, Peru, Bangladesh, El Salvador and Taiwan.

In India Andhra Pradesh, Maharashtra, Tamilnadu, Kerala, Karnataka, Orissa, Assam, Bihar and West Bengal are the important states in cultivation of turmeric. In Karnataka, it is being cultivated in Chamarajanagar, Mysore, Belgaum, Bijapur, Bagalkot, Gulbarga and Bidar districts.

Area and production

India is the largest producer and exporter of turmeric in the world having an area of 180.96 lakh hectares with the annual production of 7.92 lakh metric tonnes. Among the turmeric growing states, Andhra Pradesh stood first contributing 30% of the production

followed by Orissa, Tamilnadu, West Bengal and Maharashtra. The productivity of turmeric is 4,400 kg/hectare. India exports 49,250 tonnes valued Rs.70,285 lakhs during 2010-11. UAE, Iran, Bangladesh, Malasya and Japan are the important countries importing the turmeric.

Climate

Turmeric prefers a warm and humid climate and can be cultivated in most of the tropics and subtropics. An annual rainfall of 100-200 cm is ideal. It can be grown from sea level to 1200 m above MSL, but the optimum range is 450-900 m. It requires annual temperature range of 15-35°C. High temperature and low humidity cause slow emergence of the pseudo stem and leaves.

Soil

Turmeric can be grown in wide variety of soils. However, well-drained loamy or alluvial soils, rich in good organic matter are well suited. The pH range of 5 to 7.5 is optimum for the crop. The crop cannot withstand waterlogging. Gravelly, stony and heavy clay soils are unsuitable for the crop, because of their interference with the development of rhizomes.

Varieties

Several cultivars are distinguished in our country by the names of localities in which they are grown. The widely grown cultivars are Kasturi, Mundaga, Balaga, Yalachaga and Salam, Kadapa, Rajapuri, Amalapuram (Karnataka), Kuvvur, Amrutapani, Kothapeta, Duggrala, Tekurpet, Mydukur, Aromoor, Vontimitta, Sugandham, Nandyal, Avanigadda, (Andhra Pradesh) Erode, Salem (Tamil Nadu); Aleppey, Mannuthy Local (Kerala) Shillong, Tall Karbi (Assam); Rajpuri, Evaigon (Maharashtra); Duhgi, Jobedi, Katingia (Orissa); and Gorakhpur (Uttar Pradesh).

Based on maturity group, its cultivars are classifed as short-duration (7 months), medium-duration (8 months) and long-duration (9 months). Suganthum, Kesar, Rajapuri, Deshi, Patani, Balaga, Mundaga and Yelachaga.

Released by G.A.U.:Sugandhum, Gujarat Turmeric – 1

Released by N.A.U.: Gujarat Navsari Turmeric-1

Released by NRCS, Calicut:Sudarshana & Suguna

Released by IISR, Calicut: Prabha &Prabtibha

Released by HARS,Pottangi, Kerala: Ranga, Rashmi, Roma & Surama

Other varieties: Krishna, Kesar, Rajapuri, Roma

Export oriented variety from India: Allepy turmeric (Best in World)

Variety	Av. yield of fresh rhizomes (tones/ha)	Duration (days)	Dry recovery (%)	Curcumin (%)	Oleoresin (%)	Recommended for
BSR-1	30.70	285	20.5	4.20	4.0	Tamil Nadu
BSR-2	37.5	240-245	20.0	3.75	-	Tamil Nadu
Co-1	30.50	285	19.5	3.20	6.7	Tamil Nadu
IISR Prabha	37.47	205	19.5	6.53	15.0	Kerala and Tamil Nadu
IISR Prathiba	39.12	225	18.5	6.21	16.2	Kerala and Tamil Nadu
Kanthi	7.90	240-270	-	7.18	-	-
Krishna	9.20	240	16.4	2.80	3.8	Maharashtra
Mgha Turmeric-1	23.0	-	-	-	-	Meghalaya
Rajendra Sonia	4.80	225	18.0	8.40	-	North Bihar
Ranga	29.00	250	24.8	6.30	13.5	Orissa, Tamil Nadu, Andhra Pradesh and

						Kerala
Rasmi	31.30	240	23.0	6.40	13.4	Orissa, Tamil Nadu, Andhra Pradesh and Kerala
Roma	20.70	250	31.0	9.30*	13.2	Tamil Nadu, Himachal Pradesh, Andhra Pradesh and Kerala
Sobha	5.74	-	-	7.19	15.9	-
Sudarsana	28.80	190	12.0	5.30*	15.0	Kerala and Andhra Pradesh
Sugandham	15.00	210	23.3	3.10	11.0	Gujarat. Tolerant to pests

There are many improved cultivars available in the country. Based on maturity group, its cultivars are classified as short-duration (7 months), medium-duration (8 months) and long-duration (9 months).

Mango Ginger:

Mango-ginger is botanically related to neither mango nor ginger, but to turmeric (*Curcuma longa L*). Morphologically mango-ginger plant is similar to turmeric, but has shorter crop duration of six months. The rhizomes are pale yellow inside with lighter colour outside, have sweet smell of unripe mango when crushed. (R. M. Patel, NAU)

Cultivation

Propagation

Turmeric is generally propagated by using mother rhizomes, primary and secondary fingers. The micro-propagation protocols for rapid multiplication have been developed for turmeric.

Land preparation

The land should be ploughed three to four times thoroughly to a depth of 20-30 cm, followed by two to three harrowing and bring to fine tillth. Well-rotten FYM or compost at the rate of 40 t/ha should be mixed in the soil. After land preparation is completed, the field is laid out either into beds of 1-1.5 m width, 15- 25 cm height and of convenient length, or by forming ridges and furrows.

Selection of rhizomes

Mother rhizomes having 30 g in weight and 4-5 cm long healthy, diseases free and possess at least one developed bud. Mother rhizomes gave 33 % more production, more fiber(market price less) and contain more food.

Seed rate: 1700 to 2000 kg rhizomes/ha

Seed treatment: For early and better sprouting treated with cow dung earth slug and Agallol 0.25 % solution for 30 minutes.

Planting

Healthy and disease-free mother and finger rhizomes are used for planting. The early planting results in more yield, planting in middle of May is ideal. Rhizomes weighing 20-30 grams with two healthy buds are using for planting. Before planting of rhizomes are treated with 0.3 % Dithane M 45 and 0.1 % punialphous for 30 minutes and shade dried. The treated rhizomes are planted at spacing of 25 x 25 cm or 30 x 25 cm in beds and 45 x 25 cm in ridges and furrows method. The rhizomes are planted in a small pits of 10 cm depth and covered with soil or cattle manure. For planting one hectare 2,500 kg rhizome is required.

Earthing up

First earthing up should be given 50–60 days after planting and the next after 40 days. It cannot withstand prolonged waterlogging and also does not tolerate heavy shade.

Mulching:

In bed planting, mulching is done immediately after sowing with 15 tonnes of green leaves per hectare which is repeated 2 months after planting.

Manures and fertilizers

A basal dose of FYM @ 30 t/ha is applied at the time of land preparation. Under rain-fed conditions, a fertilizer dose of 30:30:60 or 60:30:90 kg of NPK per hectare is recommended, while in irrigated conditions the fertilizer dose up 60:30:90 kg of NPK is recommended under Kerala condition. In Karnataka, 40-50 tonnes of FYM or compost, 150:125:250 kg of NPK per hectare is recommended. The fertilizers are applied in three split doses. The whole of P_2O_5 and half the dose of K_2O are applied as a basal dose and N is supplied in two split doses after 45 and 90 days after planting, along with the remaining half dose of K_2O.

Irrigation

Turmeric can be grown as a rain-fed crop under heavy rainfall area and irrigated crop in maidan areas. In irrigated crop, depending on weather and soil conditions, 15-40 irrigations are required at 7-10 days intervals.

Inter-culture

Weeds should be controlled manually or by the use of herbicides. Usually, weeding is done thrice, at 60, 120 and 150 days after planting, depending upon the weed intensity. Early weeding may be avoided by the use of 2,4-D as a pre-emergent herbicide. Earthing-up operation is followed immediately after the application of fertilizers at different stages.

Inter-cropping and crop rotation

Turmeric also comes up well under sparse shade. It can be grown as an inter-crop in coconut and arecanut gardens. It is also grown as a mixed crop with red gram, chilli, colocasia, vegetables, maize and ragi. In wetlands, it can be rotated with paddy, sugarcane, banana or vegetables. In garden lands, rotation is done with rain-fed paddy or mixed with red gram, maize, groundnut and sunflower.

Use of growth regulators

Kinetin 75 and 100 ppm, CCC at 1000 and 1500 ppm and MH at 50 ppm increased curcumin content of rhizomes.

Harvesting

Turmeric comes to maturity in 7-10 months after planting, dependingupon the variety. The noticeable maturity indices are the completeyellowing of the leaves and the drying up of plants including thepseudostem.

Usually the land is ploughed or dug with a spade and the whole clump is lifted with the plant, including the base of the stem. While doing so, it must be ensured that the rhizomes are not injured.

The leafy tops are then cut off, the roots removed, and the rhizomes thoroughly washed with water to remove the adhering earth. The fingers (daughter rhizomes) are separated from the rounds (mother rhizomes) manually.After keeping aside the required quantity of rhizomes for planting, the rest of the bulk is cured and polished.

Yield

The yield in turmeric has been observed differ with different location and verities. However, a yield of about 20-25 t/ha of green turmeric per hectare. High yielding varieties yield up to 35 t/ha.

Storage of seed Rhizomes

- Rhizomes for seed purpose are generally stored after heaping under the shade of tree or in well ventilated shade and covered with turmeric leaves.
- Sometime the heap is plastered with mixture of soil and cow dung.
- The seed rhizomes can also be stored in pits covered with wooden planks with one or two holes for aeration.

Processing

The quality of cured turmeric is assessed on the basis of several factors, such as the curcumin content, the organoleptic character, the general appearance, size and physical form of the rhizome.The method of curing turmeric consists of boiling or steaming the prepared fresh rhizomes in water, drying in the sun and finally peeling or polishing.

The following steps are involved in the processing.

Cleaning

The harvested rhizomes are cleaned of other extraneous matter adhering to them and the roots are removed. Only the good fingers separated from the rhizomes are used for curing.

Curing

Fresh turmeric is cured to get dried commercial product. Fingers are separated from mother rhizomes. Mother rhizomes are stored for seed purpose.

In the traditional method of curing, fresh rhizomes are boiled in water just enough-to immerse them. Copper/ galvanised iron/ earthern vessels are used for the purpose. Boiling is stopped when froth comes out and white fumes appear giving out a typical odour. At this point (about 45-60 minutes) rhizomes turn soft. The stage at which boiling is stopped largely influences color and aroma of the final product. Over cooking spoils color of final product while under cooking renders dried product brittle.

In improved method of curing, cleaned fingers (approximately 50 kg) are taken in a perforated trough of 0.9 m x O.5mx 0.4 m size made of GI or MS sheet with extended parallel handle. Perforated trough containing fingers are then immersed in a pan, 100 litres of water is poured into the trough to immerse turmeric fingers. Cooked fingers are taken out of the pan by lifting the trough so as to drain water into the pan. Water used for boiling can be used for curing fresh samples Processing is to be done two or three days after harvesting. If there is delay in processing, rhizomes should be stored under shade or covered with saw dust or coir dust.

Draying

Cooked fingers are dried in sun by spreading them in 5-7 cm thick layers on bamboo mats or on drying floor. During night, rhizomes should be heaped or covered with any material that provides aeration. It may take 10-15 days for drying. Artificial drying, using cross-flow hot air at a maximum temperature of 60°C also gives a satisfactory product. In sliced turmeric, artificial drying gives a brighter coloured product than sun drying which tends to undergo surface bleaching. Yield of dry product varies from 10-30 % depending upon variety and locality.

Polishing

This operation is done in order to smoothen the rough and hard outer surface of the boiled and dried turmeric. It also improves the colour of the product from a dirty-brown to a bright-yellow.

There are two types of polishing; (i) they are Hand polishing and (ii) Machine polishing.

Hand polishing

This method is simple and involves rubbing the turmeric fingers wrapped in several folds of gunny cloth on a hard surface with the hands or by trampling them under the feet or shaking the rhizomes mixed with stones in a long narrow gunny bag or in a bamboo basket.

The improved method is through the use of a hand-operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh.

When the drum filled with turmeric is rotated, the abrasion of the surface against the mesh as well as by mutual rubbing against each other will polish them effectively.

Machine polishing

The machine used for polishing consists of a hexagonal wooden drum, mounted on a central axis and rotated by power.

These power-driven drums are gaining popularity because a higher degree of polishing (smoothness) can be attained by this method.

The capacity of these drums is also high compared to the hand-operated ones and, hence, the output is also higher.

Colouring

The colour of turmeric always attracts buyers. Thus, giving the required colour externally to the rhizome is an important step in the processing of turmeric. For this, the boiled, dried and half-polished fingers are placed in a basket, which is shaken continuously in a prepared emulsion. They are later sun-dried. The colour emulsion comprises of alum (0.04 kg), turmeric powder (2 kg), castor seed (0.14 g) or sodium bisulphate (30 g) and concentrated HC1 (30 m1).

Grading (Indian standards)

Turmeric is included in the list of spices which must have an Agmark grading before they can be exported from India. Three grades of finger turmeric, two of bulb turmeric and one grade of powdered turmeric are specified, as follows:

- Finger turmeric, other than the Alleppey variety is sub-graded into 'Special' Good' and 'Fair'.
- Alleppey finger turmeric is sub-graded into 'Good' and 'Fair'.
- Rajapore finger turmeric is sub-graded into 'Special'. 'Good' and 'Fair'.
- The maximum limit for extraneous matter in the prime sub-grades of the above grades of whole turmeric is 1.0%.
- In the case of Alleppey finger turmeric, which is exported to the United States, the content of extraneous matter according to the specifications of the American Spice
- Trade Association is usually less than 0.5%. In the case of the turmeric powder, the characteristics are more exacting.
- The maximum percentage limits are specified for moisture, total ash, acid insoluble ash and starch.
- The ASIA (1) and FDA (2) chemical and physical specification of turmeric are as follows: (1) Whole dead insects by count 3; mammalian excreta (mg/lb) 5; other excreta (mg/lb) 5; mould (% by weight) 3; insect defiled (% by weight) 2.5 (2) volatile oiV curcumin (% min) 5; moisture (% max) 10; ash (% max) 8; acid insoluble ash (% max) 1.0, average bulk index (mg/100 g) N/A.

Value-added products

The value-added products of turmeric are Curcuminoids, Dehydrated turmeric powder, Oil and Oleoresin.

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GINGER

Scientific Name: *Zingiber officinale* Rosc.
Family : *Zingiberaceae*
Indian Name : Sanskrit *Adraka - Hindi - Adrak, English : Ginger, Kannada : Shunti*

It is one of the oldest spices with a distinct flavour and pungency. Both fresh and dry (scraped or peeled and then dried) ginger is used in cooking for its aroma, flavour and pungency. Ginger is used in the production of ginger beer, ginger wine, cordials and carbonated drinks in confectionery, pickles and pharmaceutical preparations. As a medicine, it relieves flatulence, stimulates the gastrointestinal tract and acts as a rubifacient and counter-irritant. A daily intake of 5 g of ginger is reported to protect against coronary artery disease (CAD) that normally afflicts individuals who habitually consume fatty food. Ginger also increases fibrinolytic activity and thereby protects against CAD. Ginger is also used for flavouring soft drinks and medicine preparations. The essential oil and oleoresin are used in the manufacture of flavouring essences and in perfumery.

Origin and Distribution

It originated in South-East Asia, but was under cultivation in India as well as in China from ancient times. Because of easiness of carrying the rhizomes, it spread throughout tropical and subtropical regions in both hemispheres. Main ginger growing countries are India, China, Jamaica, Taiwan, Sierra Leone, Nigeria, Fiji, Mauritius, Indonesia, Brazil, Costa Rica, Ghana, Malaysia, Bangladesh, Philippines, Sri Lanka, Thailand, Trinidad, Uganda, Hawaii, Guatemala and many Pacific ocean islands.

Ginger was grown on west coast of India from time immemorial and later on its cultivation spread to various other parts mainly to Bengal and North Eastern India.

Ginger was exported from ancient Malabar coast of Peninsular India. It was the Arabs, Portuguese and the Dutch who took it to western world. 'Cochin ginger' was the most sought after commodity in spice trade between India and Europe. In India Kerala, Orissa, Meghalaya, West Bengal, Arunachal Pradesh and Karnataka are the important states in cultivation of Ginger. In Karnataka, Coorg, Chikkamagalore, Hassan and Shimoga are the important districts.

Area and Production

India is the largest producer, consumer and exporter of ginger. The annual production is about 3.85 1akh tonnes from an area of about 1.07 1akh ha contributing approximately 30 to 40 % of world production. The crop occupies the largest area in Kerala (19%) followed by Orissa (17%), Meghalaya (12%), West Bengal (12%) and Arunachal Pradesh (6%). Kerala and Meghalaya together account for nearly 40 % of the country's production. In terms of productivity, Arunachal Pradesh stands first with 7.16 tonnes/ha, followed by Meghalaya (5.14 tonnes/ha), Mizoram (5.14 tonnes/ha) and Kerala (3.44 tonnes/ha). During 2010-11, India exported 15.750 tonnes of ginger valued at Rs.12,131 lakhs.

Gujarat: Dahod,Panchmahal,Surat, Anand,Baroda & Valsad

Climate

Ginger requires a warm and humid climate. The plant thrives well from sea level to an altitude of 1500 m in the Himalayas, optimum elevation being between 300 and 900 m. A well distributed rainfall (150 – 300 cm) during growing season and dry spells during land preparation as well as before harvest are required for large scale cultivation of crop. In areas receiving less rainfall, the crop needs regular irrigation.

Soil

Ginger can be grown in a wide range of well drained soils of at least 30 cm depth, ranging from heavy laterite loams to clayey loam. Laterite loams containing not more than 30 % sand or 20 % clay and free from gravel are however preferred as they give higher yields. The ideal soils are sandy loams, red loams, clayey barns, lateritic soils and black, rich clay soils. It is very sensitive to waterlogging and therefore such situations should be avoided. The ideal soil pH range for the crop is 5.5 to 6.5.

Varieties

The local cultivars are usually named after the areas where they are cultivated. The popular local cultivars are Wynad, Manathodi, Narasapatnam, Thaiguppa and Karkala, Kuruppampadi, Maran, Nadia, Thodupuzha, Jamaica and Himachal Pradesh. The exotic varieties Rio de Janeiro and China are also popular and are in cultivation.

- Green ginger: Thingpuri, China and Rio-de- Janeiro
- Rio-de- Janeiro: Contain maximum oleoresin (10.5 %), 5.19 % fibre and Dry ginger recovery is 16-18 per cent.
- Suprabha, Suruchi, Suravi released by High Altitude Research Station, Pottangi (Orissa)
- IISR-Varada,IISR-Rajetha IISR-Mahima by IISR, Calicut, Yielded 22.6 t/ha fresh ginger
- Himagiri released by Dr. Y.S. Parmar Uni. of Hort. & Forestry, Solan (H.P.) yielded 13.14 t/ha fresh ginger.
- Wynad Manatody- contribute 50% of total production.
- Cochin ginger/Indian ginger is best in the world.

Cultivation

Propagation

Ginger is propagated by rhizomes. The synseed technology protocols for rapid multiplication and also somatic embryogenesis and regeneration methods have been developed at the IISR, Calicut. For propagation by rhizomes, carefully preserved, healthy and disease free seed rhizomes or sets, cut into small pieces of 2.5 to 5 cm length, weighing 25 to 50 g, with a minimum of 1 or 2 good buds or growing points should be used.

At the time of planting, the rhizome pieces are treated with 0.25% organo-mercurial compound or 0.3% Dithane M-45 for 10-30 minutes as a control measure against Furasiurn root-rot. If required, they may be treated with 0.05% Malathion or 0.1% Quinolphos and 200 ppm Streptocycline. About 1,500-1,800 kg sets are required to plant one hectare area. Early sowing, with the onset of pre-monsoon showers, ensures good growth and yield.

Land preparation

The land should be ploughed 4-5 times to bring the soil to a fine tilth. Beds of 1 m width, 15 cm height and 3 m length or of any convenient length are prepared at 40 cm spacing. About 2,000 beds of 3 m x 1 m size are prepared in one hectare of land. Being an irrigated crop, the ridges are formed 40 cm apart. The width of the channels between the beds is about 30 cm.

Selection of rhizome

2.5 to 5 cm long healthy finger rhizomes should be selected which have 28-56 g weight and one to two buds on each rhizome.

Planting

Spacing varies with soil fertility, cultivar, climate and management practices. Earlier reports indicated that closer spacing gave better yield. Based on trials, planting of ginger is recommended on raised beds (in order to facilitate drainage) at a spacing of 20 x 20 cm or 25 x 25 cm and a depth of 4-5 cm with the viable bud facing upwards. Seed rhizome is placed 3.5-5.0 cm deep in pit and soil is pressed over it, followed by light irrigation. The crop prefers light shade for good growth, but shade is not absolutely necessary.

Seed rate: 1200 to 1400 kg rhizomes/ha

Seed treatment:

Finger rhizomes (sets) are treated with 0.5 % Ceres solution, 0.3 % Copper oxychloride solution for 10 minutes to control soft rot.

Mulching

Mulching is essential operation in ginger and turmeric as it enhances rhizome sprouting and controlling the weeds. Immediately after planting, beds are to be mulched with 15 tonnes per ha of green leaves, which is repeated with 7.5 tonnes per ha each at 2 months and 4 months after planting. Mulching is done coinciding with weeding, top dressing and earthing up. Among different mulch materials, leaves of *Glycosmis entaphylla, Glyricidia maculata* and *Artocarpus altilis* were found good.

Ear thing up: Required at 30 days after planting to cover the rhizomes and provides support to the plants. It is essential operation to prevent exposure of rhizomes and to enhance rhizome yield and quality of ginger and turmeric.

Manures and fertilizers

As ginger is a heavy feeder, it should be well manured. Usually, it is the practice to apply 25-30 tonnes of well rotten FYM or compost per hectare at the time of planting. The manure may be applied to each hole over the seed, which is then covered with soil, or it may be broadcasted over the entire field and mixed with the soil during the last ploughing.

In addition, a fertiliser dose of 75:50:50 or 100:50:50 kg. NPK per hectare is recommended. The whole of phosphatic and half of potassic fertilizers may be applied at the time of planting. Half the Nitrogen is applied 40 days after planting and the remaining nitrogen and potassium a month after that.

The application of neem cake @ 2 t/ha as a basal dressing helps to reduce the incidence of soft-rot disease and increases the yield.

Bio-fertilizers

Ginger responds well to application of bio-fertilizers. Studies revealed that soil solarised for 30 days and incorporated with *Trichoderma* ($125g/m^2$) and amended with neem cake ($500\ g/m^2$) could control disease effectively and increase yield considerably. Treating rhizomes with *Azetobacter* and *Azospirillum* followed by application of N at 50 kg/ ha produced maximum green ginger yield of 20.34 tonnes/ ha.

Irrigation

Ginger is cultivated as a rainfed crop in heavy rainfall areas, as irrigated crop in maiden areas. Water requirement of ginger is 1,320-1,520 mm during its complete crop cycle. Irrigations are given at an interval of 10 days with a total of 16-18 irrigations are required during cropping period. Irrigation is withheld 15-20 days before harvesting of the crop. Light irrigation is given before harvesting the rhizome.

Weeding

Usually, two to three weedings are done in the whole of the growing period. The first weeding is done just before mulching and then repeated at monthly intervals, depending on the intensity of weed growth.

Crop Rotation and Inter/mixed cropping

Ginger is grown both as a pure crop and as an intercrop or in rotation with other crops. In Kerala, it is grown as an intercrop with coconut, arecanut and coffee and also in rice fallows. In irrigated areas, ginger is grown in rotation with chillies, vegetables, ground nut, ragi and maize. In

Kerala as well as in Sri Lanka, ginger forms a component of homestead farming, and is grown mixed with a variety of crops. Ginger is a very successful crop component in intercropping and multi-cropping systems. It isintercropped with vegetables (such as cabbage, beans, cucumber, and lady's finger), pulses (such as pigeon pea and black gram), cereals (maize and finger millet), oil seeds (castor, soyabean, and sunflower) and with crops such as tobacco, pineapple, tapioca, taro, *Dioscorea* and *Amorphophallus*. It can also be grown as a mixed crop with castor, finger millet, maize and red gram. Chillies-ginger-mixed cropping is prevalent in many areas.

Harvesting and Yield

Ginger is a 7-8 months duration crop. It is ready for harvest when the leaves turn yellow and start withering, after which the rhizomes become more fibrous and pungent and are better suited to the production of dried ginger.

A light irrigation is provided 4-5 days before harvesting and clumps are lifted carefully with the help of a pick-axe or a digging fork or hoe. If the crop is meant for green ginger, it is harvested in 5-6 months.

An average crop of ginger may yield about 10-30 tonnes of fresh rhizomes per hectare

Processing

The five main products of the ginger rhizome are fresh (green) ginger, dried ginger spice, bleached ginger, preserved ginger in syrup or brine and crystallized ginger. Green ginger or Fresh ginger is consumed as a vegetable spice, both when immature and mature. It is of lesser importance in world trade, but in the local market it is a major commodity. For this purpose, green ginger rhizomes, soon after harvesting are thoroughly washed in water 2-3 limes to remove any soil and dirt. Then, the damaged and diseased rhizomes are separated and graded depending upon the requirement in the market.

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Dried ginger

- In order to obtain a more pungent and aromatic spice, ginger should be harvested at the time of proper maturity and dried properly.
- For this purpose, the harvested rhizomes are soaked in water overnight and rubbed well between to remove the adhering soil.
- After thorough cleaning, they are removed from the water.
- The outer skin is removed with a split bamboo with a pointed end, taking care to see that only the outer skin is peeled as otherwise the essential oil glands beneath the skin will also get damaged and thus the oleoresin will be lost.
- The peeled rhizome is washed and uniformly sun-dried for a week. The dry ginger is rubbed together to remove dry foreign matter.
- This type of dried produce is known as unbleached ginger. Depending upon the variety, on an average, 16-25 kg dried ginger is obtained from 100 kg green ginger, i.e., the yield of dry ginger is 16-25% of the green ginger.
- Dried ginger forms the major bulk of international trade. It is exported as whole or in split forms and is ground at the consuming centres. It is also used for preparation of its extractives, ginger oleoresin and ginger oil.

Bleached ginger

- To prepare bleached ginger (white), the fresh rhizomes are peeled off and soaked in 2 per cent lime water for about 6 hours.
- The produce is then removed and dried for 5-6 days and rubbed with a piece of gunny cloth to give the desired dried appearance.

Preserved ginger

This is prepared from immature rhizomes, mostly for export purposes. Discounting green ginger preserved in brine (salt water), the two forms of processed, preserved ginger entering the market are: *I.**Preserved ginger in sugar syrup and II.Dry or crystallised ginger***

- Wherein ginger is impregnated with sugar syrup, dried and coated with crystalline sugar and must be harvested while they are still immature, tender, succulent, and mild in pungency, usually under 7 months of age.
- For processing, the salted ginger is removed from the acidified brine, washed and soaked in cold water for 2 days, changing the water several times.
- It is then placed in cold water, which is heated in syrup for 10 minutes, after which the ginger is removed and pricked with a fork.
- The ginger is then boiled in syrup for 45 minutes.
- It is left in the syrup to soak for 2 days or more, and then reboiled for 45 minutes after which it is packed in fresh syrup.
- The quantity of syrup used depends on the market for which the ginger is intended.

Ginger oleoresin and essential oil

- Ginger oleoresin (3.5-9.5%) is obtained by the solvent extraction of ginger powder using organic solvents like acetone, ethylene dichloride, etc., and it possesses the full organoleptic properties of the spice such as aroma, flavour and pungency.
- It is a blend of oil and resinoids and finds similar applications as the ground spice in the flavouring of processed foods. The oleoresin is also used in certain beverages and to a limited extent in pharmaceutical preparations.
- On the other hand, ginger oil (0.5-3.0%) is distilled from the dried spice. The product is characterized by the aroma and flavour of the spice but lacks the pungency. It finds its main application in flavouring of beverages and in the confectionery and perfumery industries.

Grading

Grading

- Dried ginger is marketed on the basis of geographical origin and the form of preparation.
- The chemical and physical characteristics of the spice differ from one producing region to another.
- Indian dried ginger is classified as Malabar ginger, Assamese ginger and Himachal ginger. But the two types of the spice which are in great demand in the world market are Cochin and Calicut ginger, which come under the Malabar ginger type.
- The bulk of our exports are of rough-scraPed, whole rhizomes. Sometimes, coated ginger is also exported. Bleached or limed Calicut ginger is mainly exported to the Middle Eastern countries.
- Cochin dried ginger is about 20 mm long and has a light brown to yellowish-gray colour, whereas, Calicut dried ginger is orange to reddish-brown in colour and is generally considered to be inferior in quality to the Cochin spice.
- Both types are graded prior to export into the following categories, according to the number of fingers on the rhizomes—B (three fingers), C (two fingers) and pieces (individual finger).

The grades of whole ginger and the specification are given in the table below.

Grade	Specification	Size of Rhizome
Calicut (NGK)	Garbled (distorted), non-bleached	Not less than 20mm in size
Calicut (NUGK)	Ungarbled, non-bleached	Small, cut pieces, <20mm in length
Cochin (NGC) NUGC	Garbled, non-bleached Ungarbled, non-bleached	Not less than 20 mm in length Small, cut pieces, not less than 20 mm in length
BGC Cochin (BUGC)	Garbled, non-bleached Ungarbled, bleached	Not less than 20 mm in length Small, cut pieces of less than 20 mm in length

The technical and physical specifications of ginger as prescribed by ASTA-(1) and FADA mould (% by weight) are: (1) insect defiled (% by weight) (2) volatile oil (%) (min.) 2; moisture (% max.) 12; ash (% max.) 5, acid-insoluble ash (% max.) 1.0; average bulk index (mg/100 g) N/A.

Value-added products

Ginger oil, oleoresin, candy, preserves, vitaminised effervescent ginger powder, plain effervescent powder, starch from spent ginger, ginger brandy, wine, beer, medicinal beverages, encapsulated ginger oil, and dehydrated ginger are some of the value-added products of ginger.

Storage of seed ginger

For good germination, the seed rhizomes should be stored properly in pits under the shade. The rhizomes usually harvested during December-January, have to be preserved for about 4 months before planting (April-May). Good, disease-free, big, plump rhizomes should be selected for seed purposes and treated with 0.25% organo-mercurial compound for 10 minutes, against soft-rot disease, and then dried in the shade. If the seed rhizome is infested with rhizome scale, it is advisable to treat it with 0.05% Malathion or Dimethoate. Then, the seed rhizomes are loosely placed in pits of convenient size to a height of 10-15 cm from the top and covered with a wooden plank. The remaining surface is plastered with mud. In certain areas, the rhizomes are loosely heaped over a layer of sand or paddy husk and covered with dry leaves.

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CLOVE

Botanical Name : *Syzygium Aromaticum* Merrill and Perry
Family : Myrtaceae
Hindi Name : Lavang
Origin : Indonesia
Plant part used : mature and unopened flower bud

The clove is one of the important tree spice crop grown in India. The clove of commerce is the fully grown but unopened aromatic dried flower bud of an evergreen tree *Syzygium aromaticum*. The term 'clove' is derived from the French word 'clou' and the English word 'clout', both meaning 'nail'. The word may have been based on the likeness of the flower bud of the clove tree to a broad-headed nail.

Clove is one of the most ancient and valuable spices of the Orient, known as far back as the 1st century. Clove is valued as a spice and for its essential oil. The volatile oil obtained from the clove bud contains mainly eugenol- (80-90%) and caryophyllene (4-8%). The major use of cloves is for domestic culinary purposes, as a spice to flavour both sweet and savoury dishes and in the preparation of pickles and sauces. Cloves, both whole and ground, are used in baked goods, cakes, confectionery, chocolates, puddings, desserts, sweets, syrups, preserves, etc. Clove is used for flavouring curries, gravies, ketchup and spice mixtures.

The inferior culls are used for the production of clove oil, which is used as a flavourant for all kinds of food products, in soap preparation, perfumery and the synthetic preparation of vanillin. Owing to the antiseptic property of eugenol, clove oil is invariably an ingredient in chewing gums, toothpastes and mouthwashes. In dentistry, eugenol is used in combination with zinc oxide for the temporary filling of cavities. It is also used for flavouring of `Kretek' cigarettes in Indonesia. It is reported to aid in digestion and is also used as an antispasmodic and counter irritant.

Cloves are acrid, bitter, aromatic, refrigerant, ophthalmic, a digestive, carminative, stomachic, stimulant, antispasmodic, antibacterial, rubefacient, aphrodisiac, appetising, expectorant, emolient, anthelmintic, sialogogue, rejuvenating, galacto-purifier, diuretic, febrifuge and tonic. They are useful in halitosis, odontalgia, ophthalmology, flatulence, colic, gastropathy, anorexia, cough, asthma, vitiated conditions of *kapha* and *pitta*, burning sensation, skin diseases, helminthiasis, agalactia, impurity of breast milk, strangury, fever, cephalagia, neuralgia, lumbago, dental caries, hyperacidity, vomiting, dyspepsia, hepatopathy, general debility and tuberculosis. The oil is also useful in catarrh, cough, bronchitis, vitiated conditions of vata, gastrohelcosis, odontalgia and ceplialalgia. Externally, the oil is used as a rubefacient and counter-irritant.

Origin and distribution

Clove is indigenous to the Molluccas Island of Eastern Indonesia. Later, it was introduced to Mauritius and later on established in the islands of Zanzibar and Pemba. The important clove-producing countries in the world are Tanzania (Zanzibar), Pemba, Madagascar and Indonesia. Clove is also grown in Malaysia, Sri Lanka, Haiti and India. In India, clove was introduced in 1800 AD by the East India company and is now cultivated in Tamil Nadu, Kerala and Karnataka. In Karnataka it is being cultivated other mixed crop in coffee, coconut and arecanut in Chikkamagalore, Hassan, Dakshina Kannada and Shimoga districts.

Area and Production

In India the clove is cultivated in an area of 2,600 ha. with annual production of 1,160 tonnes. The productivity is 400 kg/ha.

Climate

Clove grows well under warm and humid climate with annual rainfall ranging from 150-300 cm and a relative humidity of 70% and above. It grows well from sea level to an altitude of 700-900 m and a mean temperature range of 20-32°C. The clove cannot withstand high winds; therefore, windy locations should be avoided. Providing shade during the early period of growth is necessary for its good growth.

Soil

Deep red loam, black soil and laterite soils rich in humus, having a pH between 4.0 and 5.6, are found best for clove cultivation. Sandy soils and water-logged conditions are unsuitable for clove cultivation. It can be grown well in both sloping and level ground.

Varieties

Clove plantations in India are reported to have originated from a few seedlings obtained originally from Mauritius. The germplasm collections (215) made within the country and from abroad have not yielded any appreciable variability, mainly due to the self-fertilizing nature of clove. Although there are no named cultivars as such, in trade the differences of the spice are recognized on the basis of the places of their cultivation. The large, plump and bright reddish 'Penang Cloves' are considered the best in appearance, followed by the Zanzibar and Madagascar types. From India, Burliar-1 is one of the two high yielding progenies selected in Tamil Nadu, the other is from Odetham estate. One of the cultivars is also recognized by the name Amboyan clove.

Two distinct bud variants were identified, one is having bolder flower buds than the normal type (King clove) and the other one is smaller than the normal clove (Liliput clove/mini clove) the above two types differed distinctly from normal cloves. The mother cloves of two king clove types (KC-1 and KC-2) and Liliput clove (Lc-1) are collected under being evaluated at Horticultural Research Station, Yercaud. Apart from this twelve high yielding types were also identified from the survey made in the different estates at Nagercoil region.

Cultivation

Vegetative propagation

Vegetative propagation is difficult in clove. Several attempts have been made in different clove-growing areas, using terminal leafy softwood cuttings and by budding, but have been met only with occasional success.

However, the approach method of grafting using its own rootstock has been successful in clove. Generally, clove is only propagated through seeds.

Seed propagation

Clove is propagated through seed which is called the mother's of clove. The seeds are extracted from the ripe fruits (mother-of-clove) obtained from regular bearing trees. The fruits for seed collection are allowed to ripen on the tree itself and drop down naturally. The seeds are then soaked in water overnight prior to sowing, in order to dehusk them. Afterwards, only fully-developed, uniform-sized seeds, which show signs of germination by the presence of pink pedicle, are used for sowing and the remaining are discarded. Since the viability of the seeds is very short, they should be sown as soon as possible in raised nursery beds of 90-100 cm width, 15 cm height and of convenient length, at 2 cm depth at a spacing of 12-20 cm both ways. The seeds sprout in about two weeks depending on the individual vigour of the seeds and germination is completed in 40 days. If fresh seeds are sown, seed germination to the extent of over 90% may be obtained. The seedlings are very slow in their initial growth and when they are 50-60 cm tall they start branching and are transferred to polythene bags (30 cm x 15 cm) containing a mixture of good soil, well decomposed cow dung and sand (in the ratio of about 3:3:1). After they are one to two years old, they are ready for transplanting into the main field. While the seedlings are in the nursery, sufficient shade and irrigation should be provided. Age, colour of cotyledon and height of seedlings determine the time of transplanting. Nine to twelve months to two year old seedlings and are suited for main field planting. Study revealed that clove seedlings can be made ready for transplanting in one year by foliar application of GA (200 ppm).

Planting

- The area selected for raising the clove plantation should be cleared of wild growth before monsoons. For planting, pits of 60-75 cm3 are dug 6-7 m apart in rows spaced 6 m apart, about a month or two prior to planting.
- If planted as an intercrop, the spacing should be adjusted based on the spacings of the major crop. The pits are filled with a mixture of top soil, burnt earth and FYM or compost. Transplanting should preferably be done during June-August, and in low-lying areas towards the end of the monsoon in September-October. Clove prefers partial shade.
- Under Indian conditions, it is best suited for mixed-cropping in older coconut or arecanut plantations or in coffee estates. In order to provide a cool, humid micro-climate, intercropping with banana is found to be very good. In the vast majority of cases, clove is planted in garden lands together with various other crop plants.
- Under conditions in Kerala, such gardens will contain coconut, banana, jackfruit, mango and miscellaneous crop plants. Cloves can be fitted into this system without much of a problem. The sites should be selected based on the availability of light.
- In case of pure plantation shade trees namely *Acacia sp*., Albizia sp., *Subabool* and Banana are the common shade trees to be established 6-12 months prior to clove planting. Wind breaks like Casuarina and Japanese bamboo may be planted at the border of the plots.

Manure and fertilizer

Recommended doses	**Per plant**	**Per hectare**
I. Organic Manure FYM OR COMPOST		
Before planting	15 kg	3.5 tonnes
After planting	15 kg	3.5 tonnes
II. Fertilizers (NPK)		
First year	20:18:50 g	4.64:4.17:11.6 kg
After 2nd year	40:36:100 g	9.28:8.34:23.2 kg
After 5 years	100:90:250 g	28.20:20.85:58.0 kg
After 10 years	200:180:150 g	46.40:41.70:116.0

The application of coconut meal, bone meal or fish meal at 2-5 kg/ plant is beneficial. The manures can be applied in shallow trenches dug around the plant, normally about 1-1.5 m away from the base.

Irrigation

In the first 3-4 years, extreme care should be taken especially during the summer months. Plant-based water application has to be very scrupulously followed. Studies indicated that dripping of eight liters of water per plant per day, recorded the highest plant type and number of branches in the juvenile phase.

Mulching:

Mulching the soil around the base of the tree during summer conserves moisture and prevents weed growth. Dry leaves or slashed weeds are used for mulching around the base of the plant.

Weeding

The plot should be kept weed free by regular weeding. **Manures and fertilizers** The organic manure along with a half dose of fertilisers may be applied during May-June and the remaining quantity of fertilisers may be given during September-October, as a top dressing. The plants may be applied with manures and fertilisers as given below.

Inter-cropping

Clove can be inter-cropped in coconut, arecanut, nutmeg and banana plantations of the midlands. In higher elevations, it can be mixed cropped with pepper or coffee.

Harvesting

Though clove trees flower from 4-6 years of their planting, the trees generally start bearing an economic yield 18-20 years from the time of planting and the production continues for 80 years or more. The bearing between the years varies quite a lot and a bumper crop can only be expected about once every 4 years, being influenced by the weather and the previous crop load. The flowering season varies from September-October in the plains to December-January at high altitudes.

Cloves, which are the unopened flower buds, are produced on the terminal shoots of the twigs. The buds are collected when they are dull red or pink in colour and less than 2 cm long. The inflorescence is harvested without damaging the branches when the buds have reached their full size, but before they open, so that the petals together with the stamens inside form the head of the dried clove. Delayed picking, i.e., after the opening of the buds, will devalue the spice.

Yield

The yield of cloves is found to vary from year to year. The average yield at Burliar-1 is 2 kg per tree (500 kg/ha) per year. But, there are individual trees which are reported to give 8-10 kg in some years. In comparison, the average yield in Zanzibar from a well-grown bearing tree is reported to be very high (40 kg/year). Yields upto 80 kg/tree/ year have also been recorded. About 11,000-15,000 dried cloves weigh one kilogram.

Cloves are normally packed in double jet sacks of 50-60 kg capacity each.

Processing

- The appearance, size, content and aromatic characteristics of its volatile oil are the factors which decide the quality of the dried spice. Also, they should be free of mustiness and mould. The best prices are obtained for whole dried cloves of a good bold size with a bright, uniform, reddish-brown colour. The features mentioned above are, in turn, influenced to a great extent by the care taken in the harvesting, drying, cleaning and sorting operations, and the storage conditions.
- Prior to drying, the buds are removed from the stems and then piled in separate heaps for later individual drying, during which, over-ripe cloves and gleanings of fallen flowers are sorted out. Drying is undertaken as soon as possible, after the buds have separated from the clusters. If the buds are left too long in heaps they will ferment and the dried spice will have a whitish, shrivelled appearance (Khoker cloves). In sunny weather, drying may take four to five days to produce a brightly-coloured dried spice of attractive appearance.
- The correct stage of drying is reached when the base of the bud is dark brown, and the rest of the bud lighter brown in colour. On drying, the cloves retain about two-thirds of their original fresh green weight. Then another sorting is done to separate 'mother-of-cloves' and ',choker cloves'. A final thorough cleaning, sorting and grading is carried out by the exporting firms prior to packing.
- The stems remaining after the separation of the buds from the freshly-harvested clusters are dried similarly and are used to distil clove oil by the steam distillation method.
- The duration of distillation ranges from 8-25 hours depending upon the size of the still, the nature and volume of steam and the condition of the cloves. The leaves and small twigs yield clove-leaf oil. Clove-stem oil is obtained from the stems attached to the buds and flowers, and bud oil from the buds. The essential oil yield is 17- 19% from clove buds, 6% from the clove stems and 2-3% from the leaves.

Grading

Whole cloves are graded as special (Hand-picked), Grade-2, Grade-3, Ground (powdered) cloves, while the defective cloves are named as Khoker cloves, Headless cloves, Mother cloves, Extraneous matter, etc.

Value-added products

Clove oil, ground clove, oleoresins, clove-stem oil, clove-leaf oil, oil of mother of cloves and clove-root oil are some of the value-added products of clove.

Adulterants

Cloves are sometimes adulterated with headless cloves and clove stems. They may also be adulterated with Khoker cloves or mother cloves and other extraneous matter like dust, dirt, stones, clay particles and pieces of wood. The adulterants of clove-bud oil are stem oil, and clove-leaf oil. Another form of adulteration is the addition of clove terpenes, synthetic terpineol, dibenzyl or dibenzylether and acetins in clove-bud oil

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CINNAMON

Scientific Name : *Cinnamomum zeylanicum*BhemeSyn. *Cinnamomum* v*erum* Presl.
Family : Lauraceae
Indian name : Taj
Part Used : Bark
Origin : Shri Lanka
Introduction:

Cinnamon commonly known as "dalchini," derives its name from "Dar-al-chini," an Arabic term meaning -"The wood or bark of China." In India, it is also called lavanga-pattai (Tamil) Taj (Gujarati) and karuvapatta (Malayalam). Cinnamon or sweet wood or true cinnamon *(Dalchini* or *dorchini)* or Ceylon cinnamon had been prized for many centuries in the Orient and is one of the earliest known tree spices in India. Cinnamon of commerce is the dried bark of *Cinnamomum Verum*. Cinnamon is famous for its bark and leaves which are strongly aromatic. The bark has a sweet and agreeable taste. The bark, either as small pieces or powder, is extensively used as spice or condiment. It is aromatic, astringent, stimulant and carminative. It possesses the property of checking nausea and acts as an anti-emetic. Powdered cinnamon is a constituent in chocolate preparation in Spain. It is also used for flavouring cakes and sweets, candy, gum, curry powders, incenses, dentifrices and perfumes. The leaf oil is used in the manufacture of some cheaper types of perfumes, soaps, toothpastes, hair oils and face creams. It is used commercially as an agent for flavouring liquor, and also in the synthesis of vanillin. In the flavouring industry, it is used as a modifier. The cinnamon buds are as good for flavouring and spicing like the bark itself. Cinnamon wood provides a soft timber for use as a low-grade board wood. The root bark also yields 3% oil, which differs from both the stem-bark and leaf oil. It is a colourless liquid with a camphoraceous odour. It contains camphor, pinene, cineole, dipentene, phellandrene, eugenol, safrole, caryophyllene, borneol and cinnamic and benzoic aldehydes. The seeds contain 3% fixed oil, used for making candles. The seed oil is also called 'cinnamon suet' and is obtained by boiling the crushed ripe fruits, suspended in water. The oleaginous matter rises to the surface and solidifies on cooling.

The bark oil obtained from the matured stems is very little and expensive in comparison to the cost of its extraction. It is used in costly perfumes, for flavouring confectionery, in liquors and in pharmaceuticals, especially to mask the unpleasant taste of certain preparations and in soap manufacture.

In addition, the true cinnamon of commerce cassia is obtained from various sources like *C.cassia*, (True cassia or Chinese cassia) *C.burmanni*, (Indonesian cassia) and *C. lourneirii* (Saigon cassia) and *C.* tamala (Indian cassia). The other economically important species include *C. camphora, C. oliven* and *C.malabaricum.*

Difference between Cinnamon bark and Cassia bark

Cinnamon bark	**Cassia Bark**
Bark is thin and smooth	Bark is thick and rough
Bark powder is tan in colour	Reddish brown in colour
Less intense aroma	More intense aroma
Essential oil content is less (0.5-2 %)	Essential oil content is high (1-4.5 %)
Eugenol is the main content in the leaf oil	Cinnamal dehyde is the main content in the leaf oil
Flavour is good	Not so delicate flavour

Origin and distribution

Cinnamon is a native crop of Sri Lanka and the Malabar Coast of India. Besides India and Sri Lanka, the other major producer of cinnamon is the Seychelles Island, from where it has spread to Java and other places. It is also cultivated in Burma, Vietnam, China, Malayan Peninsula and Brazil. The cinnamon growing areas in India are the Naga Hills in Assam, the coastal districts of South Karnataka and the Western Ghats. The cultivated type *C. zeylanicum* is confined to the lower elevation of the Western Ghats in Cannanore, Calicut and Kottayam districts of Kerala and the lower Nilgiris of Tamil Nadu. The biggest cinnamon estate in the world is the Randathara estate of Auyarakandy near Telicherry in Kerala with an area of 85 hectares and the cinnamon produced here is considered better in quality than that produced in Sri Lanka.

Area and Production:

In India Cinammon is cultivated in an area 1,000 ha. With an annual production of 1,670 tonnes. The productivity is 1000 kg/ha. The cinnamon produced in India is being exported to about 15 countries, of which Japan, Taiwan and France are the major importers.

Climate:

Cinnamon is a hardy plants grows well under different climatic conditions, it thrides well under topical evergreen rain forests. It grows well in places from sea level up an elevation of 1000 m above MSL. The annual rainfall ranges between 150-250 cm is considered is ideal. The average temperature is 27^{o}C is suited for the cultivation of Cinnamon. Prolonged spells of dry weather are not conducive for its successful growth. However, the best cultivated cinnamon is grown at low altitudes in Sri Lanka, with an average temperature of 30°C and 200- 250 cm rainfall per annum. Proximity to the sea, humid conditions and brackish water are good for the crop.

Soil:

Cinnamon grows well in wide range of soils. In the West coast of India, the crop is confined to the laterite and sandy patches with poor nutrient status. Sandy loam soils with rich humus results high quality bark. Silicaceous sandy soil produced higher yield than other type of soil. Avoid water logged soils it gives undesirable products.

Varieties

Sweet Cinnamon, Honey Cinnamon, Camphor cinnamon, Snake cinnamon, Astringent cinnamon, etc., are some of the popular types locally cultivated in Sri Lanka and India.

Among the other improved varieties Navashree and Nityashree have also been released by the Indian Institute of Spice Research, Calicut.

Navashree

Navashree is a superior selection. It has a high and stable regeneration capacity (6-7 shoots/ year), high yield (average yield 56 kg/ha in the first 4 years), high bark recovery (40.6%), and excellent bark characteristics (bark oil 2.7% with a very good cinnamaldehyde content of 37%, bark oleoresin 8%, leaf oil 2.8%). Its very young flushes are purple, which turn green in 7-10 days. It is recommended for cultivation both in the plains and high altitudes.

Nityashree

Nityashree is also a good stable selection, which produces 4-5 shoots per year and the average yield is 54 kg/ha in the first four harvests. The bark contains 2.7% oil, 10% oleoresin and 3% leaf oil with a very good eugenol content of 78%. The young flushes are purple in colour and turn green in just 2 days. This variety is also recommended for both the hills and plains.

Other improved varieties are YCD-1

It is a cinnamon selection from Horticultural Research Station, Yercaud. It comes to harvest from third year onwards can be maintained economically for 20 years. It gives a bark yield of 359.75 kg quills and 3800 kg of dried leaves/ha with high bark recovery of 35.3 per cent. It has got

2.8 and 3 per cent volatile oil in quills and leaves, respectively. It gives a high regeneration capacity of 19.2 harvestable shoots. Quills are sweet and light pungent in taste.

Konkan Jej

The variety "konkan Tej'''was developed by clonal selection at konkan krishi Vidaypeeth, Dapoli which has gigh oil (3.2 5), cinnamaldehyde (70.23%) and eugenol ((6.93 %) and yields 789.75 g fresh bark and 3.56 kg leaf per plant.

Sugandhini

It is a selection from Aromatic and medicinal Plant Research Station, Odakkali, Kerala Agricultural university. It is recommended for cultivation in the mindlands and highlands of kerala both in open and as intercrop in coconut gradens for cinnamon leaf oil. Average leaf yield is 18 kg/tree/year and average bark yield is 1.2 kg/tree year. Leaf oil yield is 295 ml/tree/year or 125 kg/ha and the eugenol content is 94 percent in leaf oil.

PPI C-1

It is selection made at horticultural Research station, Pechiparai, Tamil Nadu. It give a fresh bark yield of 980 kg/ha. Bark recovery is 34.22%, leaf oil recovery 3.3 % and bark oil recovery 2.9%.

RRL (B)C-6

It is a selection made at Regional Research laboratory, CSIR, Bhubaneswar. Bark oil yield is 250 kg/ha. Bark is of high quality with 83.0 % cinnnamaldhyde in the oil Leaf oil contains 94.0 % eugenol.

Propagation

The most common method of propagation of cinnamon is through the seeds. Cinnamon flowers in December-January and the seed ripens in May-June. The fruits are picked when the outer pulp begins to turn black and the seeds are gathered, dried and heaped up in a shady place till the pulp rots and turns black. To free the pulp, the whole mass of seeds is trampled and then washed. After separation of the pulpy mass, the seeds are separated. They are dried in the air taking care not to expose them to the sun. If they are exposed, the seed coat cracks and causes damage to the seeds. The seeds soon lose their viability and should be sown immediately after the removal of the pulp, in raised nursery beds or pots or polyethylene bags (30 x 15 cm) filled with a mixture of sand, cattle manure and soil (3:3:1) during July-August.

Frequent irrigation is required for maintaining adequate humidity. The seeds germinate within 15-20 days of sowing.

The seedlings raised in nursery beds are transplanted into polybags or baskets 4 months after germination of the seed. Artificial shade is required for the seedlings till they are about 6 months old. According to local conditions and the growth rate of the seedlings, 10-12 month old seedlings are ready for planting into the main field.

The plants can also be propagated vegetatively by cuttings and air-layers. The hard wood cuttings treated with IBA 2500 ppm recorded 45 % rooting. 50 % rooting in hardwood and semi hardwood cuttings treated with IAA 100 ppm resulted in 50 % fruiting. 95 % of success of air-layering is obtained during September. Micro-propagation protocols for the rapid multiplication of cinnamon, synseed technology and the somatic embryogenesis and regeneration procedures have been standardized.

Cultivation

Preparation of land and planting

The area selected for planting cinnamon is cleared and 50 cm3 pits are dug at 2 m x 2 m or 3 m x 3 m spacing. They are then filled with compost and top soil before planting. As in the case of other tree spices, cinnamon is also planted during June-July, to take advantage of the monsoon for the establishment of the seedlings.

In each pit, 5 seedlings can be planted. In some cases, the seeds are directly dibbled in the pits that are filled with compost and soil. Partial shade in the initial years is advantageous for rapid growth and development of healthy cinnamon plants. Care should be taken to provide a drainage channel from the pit along the slope, since water stagnation is detrimental to the young seedlings.

Manures and fertilisers

Cinnamon responds well to fertilisers. Apart from 20 kg of FYM, a dose of 20g N, 20g P_2O_5 and 25g K_2O per seedling is recommended in the first year. The dosage is gradually increased to 50kg FYM/ compost, 200g N, 180g P_2O_5 and 200g K_2O, for grown up plants of 10 years and above. The fertilisers should be applied in two split doses, in May-June and September-November.

Irrigation

Cinnamon is raised mostly as an unirrigated crop. However, in the initial 2-3 years, watering is done twice a week during summer months. The quantity of water depends on the soil moisture level and the growth of the plants.

Inter-culture

Inter-cultivation is confined to 2 weedings during June-July and October-November in a year. This is done by digging the soil around the bushes, once, during August-September. Mulching the soil around the plant with the weed and grasses or with spent cinnamon leaves after the distillation for oil, and then covering them with the soil is very effective in conserving soil moisture in the root zone.

Shade Management

For Cinnamon crop, it has been found that the development of shoots tends to proceed more vigorously under the influence of partial shade than in the open. It is considered advisable in the interest of proper development of young shoots to set aside tall trees at intervals of about 25 to 30 metres when a large area is cleared for cinnamon cultivation. Regular clearing being confined to scrub single and all short trees and miscellaneous vegetation. The shade trees should be so spaced that they promote the play of the sun on the cinnamon bushes so that the quality of the bark may not suffer for the want of proper light.

Pruning/Coppicing

In about 2 years, the seedlings grow upto a height of 2 m and form healthy bushes. The young trees are cut close to the ground to a height of 15 cm from the stump to encourage side shoots. This process is called coppicing. This is done until the whole tree assumes the shape of a low bush with the side shoots springing forth in profusion.

Harvesting and processing of cinnamon

For the preparation of the quills, the plants are harvested 3 years after planting. The crop is harvested in the months of May and November, by cutting the shoots for the extraction of the bark. As soon as the rain stops, the cutting of shoots for peeling of the bark is commenced.

At this time the new growth of bushes is stopped and the trees have mature leaves. This stage is also indicative of the free flow of sap between the bark and the wood. This is the appropriate stage to obtain the best quality bark. After cutting, young shoots spring up from the stump which will be ready for removal in the subsequent seasons within 18 months. The bulk of the bark is obtained from the shoots that are 1 to 2 years old. The shoots selected for cutting are usually 1.5-2 m long and 2 to 2.5 cm thick. To judge the suitability for peeling, the peeler makes an oblique cut and lifts the bark to see whether it separates easily with a free flow of sap that facilitates easy peeling. If there is any difficulty in peeling, the peeler rejects the shoots. The shoots that are ready for peeling are removed from the stumps from the terminal ends of shoots.

Peeling

Peeling is done with a small knife with a round edge at the end. The cut stems or sticks are given longitudinal slits from one end to the other. By working the knife both ways, the two halves of the entire bark are removed. If the bark does not peel easily, the sticks are rubbed in between hard pieces of wood which enables the easy detachment of the bark.

Rolling

The barks are packed together and placed one above the other and pressed well. The length of the bark slip is reduced to 20 cm, which are then piled up in small enclosures made by sticks. They are then covered with dry leaves or mats to preserve the moisture for the next day's operation and also to aid in the slight fermentation.

Piping

Preservation of moisture is very important for the subsequent operation, known as piping. After peeling and rolling, the slips (quills) are bundled and taken to the piping yard for the piping operation. Three sticks are driven into the ground in such a way that they cross each other at a height of 30 cm from the ground level. This serves as a support to keep the fourth stick resting on the knot. The operator sits down and places the slips one by one on the fourth stick to scrape off the outer skin with a small curved knife. The scraped slips are sorted into different grades according to their thickness.

The graded slips are rolled to form pipes by fitting them over the outer edges of the slips. Soon after piping, they are allowed to dry. The bark-free onesof finest, smoothest quality are graded as "00000", the coarsest being grade "0" and the remaining ones are graded as chips, pieces, quillings (broken pieces) and 'graded featherings'. The outer bark possesses a slightly acidic flavour and its removal enhances the delicate aroma. Good quality cinnamon should not be thicker than a thick paper. It should be light brown with wavy lines and produce a fractured sound when broken. When chewed, it should become soft, melt in the mouth and sweeten the breath.

The bark of a large shoot is coarse, whereas the tender ones are very thin and straw coloured. The shoots which are exposed to the sun are said to be more spicy than those grown under the shade. The best quality cinnamon is always obtained from the thin bark from the shoots in the centre of the bush and from the middle portion of the shoot. Commercial bark should not be more than 0.5 cm thick and the thinner the bark the better the grade. Broken quills are exported as quillings and the inner bark of twigs and twisted shoots as feathering. They are used mainly for grinding or for the distillation of cinnamon oil.

Yield

Under favourable conditions, when the plants reach a height of 1-2 m. after two or three years of transplanting, the first cutting is made. About 65-125 kg of quills can be obtained per hectare from the first crop. When the trees are 10 or 11 years old, 225-300 kg of quills per hectare can be obtained normally. Barks which cannot be taken out like tubes are called quillings and the scraped pieces are called 'feathering'. In addition, about 70 kg of quillings and featherings are obtained from one hectare of cinnamon.

Leaf and bark oil from cinnamon

The leaf and bark oil of cinnamon can be obtained by distilling the dried cinnamon leaves and bark, respectively. The dried cinnamon leaves are steam distilled in special distilleries. About 4 kg of bark oil can be obtained from a hectare of cinnamon plantation.

Cinnamon bark oil contains cinnamic aldehyde which is the principal aromatic substance and eugenol. The clips yield 0.5-1.0% oil. The higher the cinnamic aldehyde content, the higher is the price. The leaves yield 0.5-0.7% oil, and the oil contains eugenol and cinnamic aldehyde.

Value-added products

Whole and ground cinnamon, the essential oils of the leaf and bark, seed oil, root-bark oil and oleoresin are the value-added products of cinnamon.

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FENUGREEK

Scientific Name :*Trigonella foenumgraecum L.*
Family :Fabaceae
English name :Fenugreek, Greekhayes
Indian names :Methi, Methe (Hindi, Sanskrit), Menthya (Kannada), Ventayan, Uluva (Malayalam), Vendayam, Venthiyam (Tamil).

Fenugreek, commonly called Greekhayes or *Methi,* is the dried ripe fruit of the pulse Trigonella *foenum-graecum* L. It is cultivated as a leafy vegetable, condiment and as a medicinal plant. The fenugreek seeds contain many substances like protein, starch, sugars, mucilage, mineral matter, volatile oil (0.02%), fixed oil, (7%) vitamins and enzymes. The seeds are rich in amino acids. The seeds also contain the sapogenindiosgenin. The fenugreek leaves and stems are rich in calcium, iron, carotene, ascorbic acid and protein (3-5%).

Commercial uses

- As a spice, fenugreek adds to the nutritive value and flavour of foods.
- Fenugreek is a popular ingredient of bread known as 'hubla' in Arabs, Egypt and Ethiopia.
- Young plants, tender shoots and the aromatic leaves constitute a very much-liked green culinary preparation in the form a *sag.*
- The seeds are eaten either boiled or raw with honey in Greece.
- In the United States, the seeds are used in the manufacture of clustrey and in various spice blends.
- In Gujarat and Maharashtra, fenugreek flour is used in the preparation of chapathi.
- Fenugreek seeds are used extensively as a condiment in curries, in dyeing and in medicines.
- The extract of seeds is used with other aromatic substance in making artificial maple flavouring.
- The flour of fenugreek seed is mixed with wheat flour to form a nutritious and delicious diet.
- Fenugreek paper paste, developed at the Cardamom Research Institute (Spices Board) is used for the coating of bamboo mats, for drying black pepper, and for yielding better quality and more hygienic paper.

Medicinal properties and uses

- Medicinally, the leaves are refrigerant and aperients and are given internally for vitiated conditions of *pitta.*
- Fenugreek is anti-diabetic and lowers blood cholesterol levels.
- They ward off vomiting, cough, useful in piles.
- According to Yunani physicians, medicinal properties of fenugreek are sliming down the body, dissolution of oedema and swellings of the wounds, strengthening the body, aphrodisiac or simulative of the urge of sex and invigorative to the nervous tissue.
- Eating salad of fenugreek leaves increases the power of memory.
- For control of pimples on the face, grind fenugreek leaves finely with a little quantity of water. Apply this paste on face as an ointment before you go to bed in the night. Fenugreek leaves are useful in cases of feeble digestion, dysentery and also in rheumatism.
- Fenugreek seeds are demulcent (i.e. cooling and soothing) and diuretic (causing profuse urination). They are carminative (removing gas from the digestive tract) and astringent.
- The seeds also find application in the synthesis of sex hormones as oral contraceptives.
- The seeds are good for the elimination of bad breath and body odour.

- The seeds are also used in hair tonic preparations.
- Seeds augment hunger and bring about contraction of the intestines.
- Seeds are roasted, powdered and give in infusion or a weak decoction, which is very beneficial in dysentery.
- Paste prepared from fenugreek seeds when rubbed frequently on the face increases the luster of the skin.
- Seeds are used to induce child birth and to increase breast milk production.
- Debitterized fenugreek seeds can be made into soup, a curry, candy and thus incorporated in bread or chapatti, is a very valuable supportive therapy for diabetics.
- It is not advisable to take fenugreek seeds during pregnancy.

Origin and distribution

Fenugreek is indigenous to countries bordering the eastern shores of the Mediterranean, extending to Central Asia and Southeastern Europe. An independent origin also exists in Ethiopia. It is grown in India, parts of North Africa, Argentina, Southern France, China, Pakistan, Morocco and Lebanon. In India, Rajasthan, Gujarath, Utter Pradesh, Andhra Pradesh, Tamil Nadu, Haryana, Maharashtra and Punjab are the major states.

Area and Production:

Fenugreek is the third largest seed spice in India after coriander and cumin. In India, Rajasthan (84%) and Gujarat (15%) are the major producing states followed by Uttar Pradesh (1%). The total area in India is around 43,250 hectares and the production of 57,440 tonnes per annum. The productivity is 1,300 kgs/ha. The major international markets for fenugreek seeds are Saudi Arabia, Japan, Sri Lanka, Korea, Singapore, UAE, the Netherlands and the United Kingdom.

Climate

Fenugreek can be grown in the tropics and in temperate regions. It is grown from sea level upto an altitude of 2000 m. It requires a moderately cool climate for its proper growth and high yield. It is fairly tolerant to frost, but is most vulnerable to frost damage at the flowering and early grain formation stages. Cloudy weather and high humidity, particularly during active grain-filling period, increases the incidence of aphids and powdery mildew, which adversely affect the yield as well as the quality. It can be grown either as a rain-fed or irrigated crop.

Soil

Fertile and well-drained loamy or sandy or clayey loam soils are best suited for fenugreek cultivation. However, it can be grown in all types of soils which are rich in organic matter, with good drainage. It also tolerates more salinity compared to other leguminous crops. However, saline and acidic soils should be avoided. The optimum pH for its best growth and production is 6 to 7.

Varieties

Main cultivars in fenugreek are

1. Non-scented or Deshi or Common methi

Quick growing and upright plants with white flowers. Pods are straight, 8-10 cm long containing 10-15 seeds.

2. Scented

Slow growing types, cultivation is confined to North India. Kasuri methi, Marwari methi and Champa methi come under this group.

The salient features of the improved varieties of fenugreek are given below.

RMt 1

Its plants are semi-erect, tall and moderately branched with bold, typically yellow grains. It is moderately resistant to root-rot and tolerant to powdery mildew. It matures in 140–150 days with an average yield of 14.7 q/ha.

RMt 143

Its grains are bold with typical yellow colour. It is moderately resistant to powdery mildew. It takes 140–150 days to mature with an average yield of 16 q/ha. It is especially recommended for heavier soils of Chittor, Bhilwara, Jhalawar and Jodhpur area.

Co 1

Its plants are short and green with medium-sized, brownish-orange seeds. It is tolerant to root-rot. It matures in 95 days with an average yield of 6.80 q/ha.

Rajendra Kanti

Its plants are tall and bushy green with medium-sized, golden-yellow seeds. it is moderately resistant to powdery mildew, caterpillar and aphids. It matures in 120 days with an average yield of 12.50 q/ha.

Lam Selection 1

Its plants are bushy, green with medium-sized, golden yellow seeds. It is tolerant to root-rot, powdery mildew, caterpillars and aphids. It matures in 90 days with an average yield of 7.40 q/ha.

HM 103

Its plants are bushy, semi-erect with bold, yellow, attractive seeds. It is moderately resistant to leaf-spot disease. It matures in 140–150 days with an average yield of 20.1 q/ha.

HM 57

This variety is late maturing and is recommended for cultivation in Haryana. It gives an yield of 16.0 q/ha.

Hissar Sonali

Its plants are bushy, semi-erect with bold, yellow, attractive grains. It is moderately resistant to leaf-spot and root-rot complex diseases. It matures in 140–150 days with an average yield of 19.0 q/ha.

ML-150

This hybrid was derived from the cross T8 x T36 and released for cultivation in Punjab in 1995. The variety has more pods, matures early and produces 18.9 and 18.2% higher grain and fodder yields, respectively, compared to T-8.

Prabhat (NLM)

This is the most suitable variety for Gujarat and Rajasthan. It normally yields 15-20 q/ha, but under favourable conditions, it yields as high as 25-28 q/ha.

Pusa Earl Bunching

A high yielding variety recommended for Andhra Pradesh. Matures in 90 days with an average yield of 740 kg/ha. Plants are tolerant to powdery mildew, root rot, caterpillars and aphids.

Another varieties are Kasuri Selection, (vegetable purpose), EC- 4911,Guj. Fenugreek-1, IC-9955

Varieties for Gujarat

Gujarat Methi-1

It is a variety recommended for Gujarat. Matures in 110-120 days with an average yield of 1814 kg/ha. Plants are tolerant to powdery mildew and aphids.

Gujarat Methi-2

It is a high yield variety recommended for Gujarat. Matures in 110-120 days with an average yield of 1920 kg/ha. Plants are tolerant to powdery mildew and aphids.

Cultivation

Propagation

Fenugreek is best grown as an annual crop from seeds which are sown following the broadcast or the line sowing method.

Land preparation

The land should be thoroughly prepared by repeated ploughing and harrowing. Beds of convenient size (3 x 2 m) are prepared at the same time. For an irrigated crop, irrigation channels are made along the alternate rows of beds.

Sowing

The ideal sowing time for fenugreek in Northern India is from the last week of October to the first week of November. In the southern parts, it is grown both in the kharif and rabi seasons. In the *kharif,* the yield is less than in the rabi crop. Sowing should be done from the second fortnight of June to July end, in the *kharif* crop and for the *rabi* crop, first fortnight of October is the best sowing time.In Gujarat, sowing time is last week of September or first week of October.

If the broadcasting method is followed, the broadcasted seeds are raked lightly to cover them. Line sowing is done by drilling the seeds 30 cm apart in rows with a plant-to-plant spacing of 10 cm. A spacing of 20 x 30 cm is followed in Rajasthan. The seed should not be sown deeper than 5 cm. A seed rate of 15-25 kg for the seed crop and 30-35 kg for the leafy vegetable crop per hectare is sufficient. The seeds are soaked in water for 2 days prior to sowing to enhance germination. The seeds may be soaked in a cycocil solution at 50-100 ppm for improving germination and enhancing seedling growth. Soaking the seeds in a solution of 0.6% EMS is recommended for improved germination and survival of seedlings. The seeds should be treated with *Rhizobium* culture before sowing. The seeds germinate within 6-8 days after sowing. The line sown crop is thinned within the row at the 3 to 4- leaf stage to retain 1-2 plants per hill.

Manures and fertilisers

FYM or compost @ 10-15 t/ha should be added to the soil at the time of land preparation. The recommendation and methods/time of application of inorganic fertilisers differs from place to place. The recommended fertiliser doses are 40:40:0 kg/ha of NPK. At the time of sowing, the entire dose of NP is drilled in the soil, or half the quantity of N along with the entire quantity of P is applied basally and the remaining part of N is applied 30 days after sowing as a top dressing. The quantity of N may be reduced if the soil fertility is high. Two foliar sprays of urea (1%) at about 45 and 60 days after sowing gives a better economic green-leaf yield as well as seed yield per unit area. A fertilizer dose of 20:40:00 kg NPK/ha along with 10 kg/ha sulphar and 5 kg/ha azospirillum culture is recommended for Gujarat conditions to obtain maximum growth and yield.

Irrigation

The first irrigation should be given immediately after sowing. The crop requires about 5-7 irrigations in all. It should be irrigated at IW/CPE ratio of 1.0 and 0.40. The number of irrigations required, of course, depends upon the type of the soil and evapo-transpiration potential prevailing during the season. In Rajasthan, a good fenugreek crop needs about 8 irrigations. The number of irrigations may be reduced to 4-5 in heavy soils with good water-retention capacity. The distribution of irrigations during the growing season should be such that the crop does not suffer any water stress during the pod- and seed-development stages. The maintenance of optimal soil moisture is essential to prevent blossom and fruit drop.

Inter-culture and weeding

Two hoeings and weedings are enough to keep the crop well aerated and weed free. The first hoeing and weeding is done at the time of thinning 25-30 days after sowing, and the crop is earthed-up. The second weeding is done at 50-60 days after sowing. Tipping of the young shoots is done after 10-30 days of sowing. This is done at a height of 4-5 cm from the ground level, if the crop is grown for leaf. A pre-planting application of Fluchloralin or Pendimenthalin @ 0.75 kg/ha supplemented with hand weeding 50 days after sowing and earthing-up of the crop will keep the weeds under check.

Use of growth regulators

A spray of ascorbic acid at 250-450 ppm improves the plant growth, enhances flowering, seed number and size. GA3 spray @ 10-100 ppm concentration enhances the internodal length, height and number of leaves.

Harvesting and Yield

The crop takes 50 to 60 days for flowering after sowing and takes about 80 to 90 days for maturity after flowering, or the crop duration varies from 70 to 150 days depending on the variety. The harvesting should be done when the crop has turned yellow and most of the leaves, except the top ones, have fallen off. The grain will shatter if the harvesting is delayed beyond this stage.

The harvested plants are stacked in small bundles. After drying them in the sun for 4-6 days, the grains are separated by beating the bundles on the threshing floor or by using a mechanical thresher. The grains are cleaned by winnowing and then stored. The average grain yield would be around 10-15 q. Yields as high as 30 q/ha can be obtained under favourable conditions and good management.

Storage

The dried and clean seeds are filled in bags and stored in damp-free, aerated stores. On a commercial scale, the seeds are cleaned with the help of a vaccum gravity separator or a spiral gravity separator. To get good prices and easy marketing, the produce should be graded and stored properly. The seed can be stored for 2 years.

For seed purposes, the seeds could be stored in 700-gauge polyethylene bags for higher viability and vigour with 9% moisture content after treatment with Thiram, at an equibrium relative humidity of 40%.

Grading

Fenugreek seeds are graded as 'Special', 'Good' and 'Fair' and the grade specifications (%) are as follows.

	Special	Good	Fair
Inorganic foreign matter	0.25	0.50	1.00
Organic foreign matter	0.50	1.50	2.50
Damaged, discoloured and weevil infested	0.50	3.00	5.00
Shrivelled and immature green	1.05	3.00	5.00
Moisture	10.00	10.00	10.00

Value-added products

The value-added products of fenugreek are fixed oil (7%), volatile oil (0.02%) and oleoresin. The fixed oil consists of fatty acids like linoleic, oleic and linolenic acids. It has marked drying properties. The dried oil has a disagreeable odour and a bitter taste. It is insoluble in ether and is golden-yellow in colour. The volatile oil is brown in colour and slightly odorous.

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CUMIN

Scientific Name :*Cuminum cyminum* L.
Family :Apiaceae/ Umbelliferae
English name :Cumin
Indian names :Jiro, Jeera, Zira or Safoid Jeero or Zeera (Hindi), Sofaid Jiro or Zeera (Bengali and Punjabi), Jiru or Jeeru (Gujarati), Jeerige (Kannada),Zyur (Kashmiri), Jeerakam (Malayalam), Jeregire (Marathi), Jira, Jeera (Oriya), Jiraka, Jiro (Sanskrit), Zero(Sindhi), Ziragam (Tamil), Jidakara (Telugu)

Cumin or *Safaid jeera (Cumin urn cyminum* L.) is one of the oldest spices known to mankind. It is the ripe fruit of a slender herb. Cumin seeds are yellowish to greyish-brown and have an aromatic odour due to the presence of an aromatic alcohol, cuminol, and a spicy somewhat bitter taste, and are extensively used as a condiment. Cumin is used as an essential ingredient in all mixed spices and curry powder for flavouring soups, pastries, stews, sausages, pickles, cheese and for seasoning bakery products such as bread and cakes. Cumin oil is used in soaps, perfumery and for flavouring liquors and cordials. The absolute is superior to the oil for flavouring. Cumin aldehyde is also used in perfumery. Cumin seeds yield a volatile oil (2.5 to 4.5 %), the chief constituent of which is cuminaldehyde (20-40%) which is used in perfumery.

It is also used as a ingredient in many *Ayuruedic* medicines. It is prescribed as a stimulant and carminative in indigenous medicines. It is an astringent and is useful in flatulence and griping, and in conditions of diarrhoea and dyspepsia. Cumin seeds are now chiefly used in many veterinary drugs. The distillation-residue water of the oil is given to children as carminative and is useful in flatulence and griping. The residue left over after the extraction of volatile oil contains 17.2% protein and 30% fat. It can be used as a cattle feed. The fixed oil could also find use in the oil, fat and soap industries.

Origin and distribution

Cumin is a native of Egypt, Syria, Turkey and the Eastern Mediterranean region. It is an important cash crop of India, Argentina, Cyprus, Denmark, Mexico, USSR, Pakistan, Syria, Iran, Morocco, Turkey, China, Southern Russia, Indonesia and Japan. Iran is the major world exporter of the cumin seed known as 'green cumin'. In India, it is cultivated on a commercial scale in Rajasthan, Gujarat, Tamil Nadu and to some extent in Uttar Pradesh, Punjab and Madhya Pradesh. Gujarat is the leading cumin seed producing state in India accounting for about 52% of the production. The area under cumin in India was about 2,96,990 hectares and production about 1,38,220 tonnes during 2001-02. There are several types of cumin well-known in the international trade. These are Iranian cumin, Indian cumin, Egyptian cumin, Turkish cumin and cumin from other regions.

Area and Production:

In India the cumin is cultivated with an area of 3.77 lakh hectares with an annual production of 1.56 lakh tonnes. The productivity is 400 kg/ha. (2009-10). About 32,500 tonnes of cumin is exported earning a foreign exchange of Rs.39.59 crores (2010-11).

Climate

Cumin thrives well in tropical and sub-tropical climates. It can be grown from sea level upto an elevation of 1800 to 3000 MSL. It flourishes well in a mild cool climate rather than the hot plains. It is grown as a *rabi* crop during October-November.

In areas where the atmospheric humidity is low during the months of February and March, which coincides with the flowering and fruiting periods, it induces the development of diseases like powdery mildew and blight and insect pests to which the crop is highly susceptible.

Soil

Cumin can be cultivated in all types of soils but a well-drained, medium to heavy textured, medium to highly fertile soil with a good water-holding capacity is ideally suited for its cultivation. Sandy loam or loamy soil is supposed to be the best for its successful production. A soil pH range between 7.0 to 9.5 is reported to be optimum. The crop can tolerate salinity where other crops fail to grow. The incidence of wilt disease is higher in light-textured soils.

Improved varieties

There are four cultivars of cumin viz. (1) tall, (2) dwarf, (3) pink flowered and (4) white flowered. The pink flowered variety yields better than the white flowered variety.

Gujarat cumin-1

This variety gives 23% higher yield than MC-43. It has the capacity to yield 700 kg/ha and has better resistance to wilt and powdery mildew diseases. This variety is also free from lodging and seed shattering. The crop duration is 105 days.

Gujarat cumin-2

This is a pure line selection from M2 of y-irradiated seeds of MC-48. The plants are bushy with a good branching habit. It gives an average yield of 921kg/ha. It is moderately resistant to *Fusarium* wilt, *Alternaria* blight and powdery mildew diseases. The variety matures in 100-105 days.

Gujarat cumin-3

This variety (culture selection 84-1) is derived by recurrent selection from an introduction from West Germany (EC 232689) received through NBPGR, New Delhi. It is the first wilt-resistant variety of medium maturity (105-110 days). The plants are a bushy type (21.8 cm). The variety produces 999 kg/ha and possesses 3.3% essential oil. The seeds are pungent with a good aroma and are dark grey in colour.

Gujarat cumin-4

Arid and semi-arid regions of Gujarat state plant height: 31 cm; bushy habit, medium tall, basal branching from first node, dark purple petals and dark green foliage; late maturity (110-115 days). It gives an average yield of 1253 kg/ha. It has resistant against cumin blight disease.

S-404

This is an old selection from local germplasm made at the Spices Research Station, Jaudan, Gujarat Agricultural University, Gujarat. It gives an average yield of 350 kg/ha and is moderately resistant to powdery mildew disease. The crop duration is 105 days.

RS-1

It is developed in Rajasthan. Slightly late maturing with bold hairy aromatic seeds. It gives 10 to 12% higher yields than the local varieties.

MC-43

Medium duration variety (110-115) days) evolved at Gujarat Agricultural University, Jagudan. Tolerant to wilt and blight diseases. Seed yield 580 kg/ha.

UC-220

This variety produces about 208 kg seeds having a volatile oil content of 3.53% in seeds and yielding about 7.34 kg of oil.

UC-217

The seed yield in this variety is 218 kg and the oil recovery is 7.42 kg/ ha. The volatile oil content of the seeds is 3.4%.

JC-147

This variety can yield 269 kg seeds from which 9.16 kg of volatile oil could be recovered. The seeds contain 3.4% volatile oil.

RZ 19

Its plants are erect with pink flowers and bold pubescent grains. It is more tolerant to wilt as well as blight. It matures in 120–140 days with an average yield of 5.6 q/ha.

RZ 209

Its plants are erect with pink flowers and bold, grey, pubescent grains, resistant to wilt and blight diseases, it matures in 140–150 days with an average yield of 6.5 q/ha.

UG-198

This is highly tolerant to wilt and is very rich in volatile oil (5-6% compared to 3% in other varieties), but its grains are some what fragile and are not suitable for marketing.

UG-223

This variety can yield 301 kg of seeds and the oil recovery is 10.23 kg/ha. The seeds contain 3.40% of essential oil.

Sel. 7-3

This variety has been released from the Indian Institute of Agricultural Research, New Delhi. It is a high yielder and is resistant to wilt disease.

CJS-182

This variety was released from the Indian Agricultural Research Institute, New Delhi. This is a high yielder preferred for commercial cultivation.

The exotic cultivars EC-232684, EC-243373, EC-243375 and EC-109635 are found resistant to *Fusarium* wilt disease.

Propagation

Cumin is propagated through seeds and the seed rate varies with the method of sowing. The broadcast method requires more and the line sowing requires less quantity of seeds.

Land preparation

The root system of the crop is confined to the upper six inches and, hence, shallow cultivation is advised. The porousness and friableness of the soil plays a very vital role in germination and crop growth. The land is prepared well by ploughing and planking. Plots of 2 x 2.5 m are made after the final preparation of land, just before sowing.

Sowing

The best time for sowing is the first fortnight of November. If the soil moisture is not adequate, a pre-sowing light irrigation should be given prior to the tillage operations. However, sowing can be done up to 15th December. The late sowing of the crop results in reduced in yield and increased infestation of insect pests and diseases. The sowing of seeds can be done either by broadcasting or line sowing. In case of the broadcasting method of sowing, generally 10-20 kg seeds/ha is required, whereas in line sowing 9-12 kg seeds/ha is needed. In order to hasten germination, soaking the seeds with Potassium nitrate (100 ppm) for 24 hours is best. Seed treatment before sowing is a must, which can be done by using Agrosan GN or Difoltan at 3 g per kg of seed. Line sowing is done at 22.5 to 30 cm x 15 cm spacing and is preferred over broadcasting. The depth of sowing should be 1.5 to 2 cm. If sowing is done properly, the seeds germinate in 5-7 days.

Manures and fertilizers:

For Gujarat conditions, It is recommended to apply well rotten FYM @10-15 t/ha to the field at the time of land preparation. In addition, an application of 15:15:15 kg NPK per hectare is considered to be optimum for the satisfactory growth of the crop. Half the dose of N, the whole of

P_2O_5 and K_2O may be applied as a basal dose followed by the remaining half of N at 30 days after planting, as a top dressing.

Irrigation

Light irrigation has to be given just after sowing and the second after 7-8 days of sowing. The crop has to be irrigated at IW/CPE ratio of 0.7. The irrigation interval between two irrigations can be kept at 12-15 days, taking into consideration the climate and the soil type. The crop requires totally 4-5 irrigations. It is essential to provide irrigation at the time of flowering and seed formation. Irrigation should be withheld at the time when the crop is maturing as this may adversely affect the seed quality.

Inter-culture

The first weeding should be done 30-40 days after sowing. At the same time, the plants are also thinned to a spacing of 12-15 cm within the rows. Another 1-2 weedings will help in better crop growth. The herbicides, Terbutyrin (0.5 kg/ha) or Oxidiazone (0.5 kg/ha) or Pendimethalin (1.0 kg/ha) are recommended for the control of weeds.

Diseases

Cumin wilt

This is caused by *Fusarium oxysporum*, *F. cumini* and *F. equisetti*. The organism can infest the plant at any stage of growth. The infected plants will wilt and die. It has been estimated that crop losses due to this disease vary from 70% to 80%. Although control of the disease is rather difficult, the severity of the disease can be minimised by the use of healthy and disease-free seeds, treating the seed with a mixture of Captan and Bavistin @ 4 g/kg of seed before sowing, fallowing, etc.

A three-year crop rotation sequence to accommodate cumin once in three years and deep summer ploughing and soil solarisation during summer months is effective. Organic amendments like neem cake are also useful in checking wilt. The exotic lines UC-198 from Egypt and UC-199 from Libya are found to be more resistant to wilt.

Cumin blight

This disease is caused by *Alternaria burnsii*. The blight-infected plants show dark brown lesions on the leaves, and the stem and tops tend to bend downward. The infection spreads rapidly if there is cloudy weather and it becomes very difficult to protect the crop in the advanced stages of infection. The plants are susceptible to this disease at the flowering stage. In order to control this disease, seed dressing with Bavistin or Captan (4 g/kg) or Dithane M-45 (2 g/kg) and a foliar application of Dithane Z-78 at the concentration of 0.2% or Blitox-50 at fortnightly intervals is recommended.

Powdery mildew

This disease is caused by *Erysiphe polygoni*. The whole plant becomes almost white with powder, and does not exhibit proper seed formation. In the initial stages of the disease, the crop should be sprayed with a 0.3% solution of wettable sulphur/Dinocop (0.25%), Karathane, or 0.2% Calixin at 15 days' intervals commencing from 45 days after germination, or dusting the crop with 20 to 25 kg of Sulphur dust per hectare would also effectively control the disease. Witches broom, caused by phytoplasma, has also been reported to affect cumin.

Harvesting and yield

The crop will be ready for harvest in about 80 to 120 days after sowing. At this stage, the leaves of the plant become yellow. The crop is harvested before the fruits shatter, by uprooting the whole plant in the morning. The uprooted plants are stacked for 2-3 days in the sun for drying. The seeds are separated by rubbing the plants manually or beating them with bamboo sticks. The clean

and dried seeds are filled in gunny bags lined internally with a polyethylene sheet and stored in a cool dry place till they are marketed.

A disease-free field receiving the above package of practice would easily produce 8 to 15 quintals of cumin seeds per hectare.

Processing

The dried fruit or seed is crushed and distilled immediately to obtain the essential oil; steam distillation is usually carried out. The oil recovery ranges from 2.5 to 4.5%; older seeds yield lesser oil. On an average, oil yield of 25-30 kg/ha is obtained.

The volatile oil is colourless or pale yellow, turning dark on storage. The oil could also be extracted by the Super-Critical Fluid Extraction (SCFE) process.

Cumin oil is often adulterated with synthetic cumin aldehyde, the presence of which in small quantities cannot be detected by routine analysis, and higher percentages affect the optical rotation. In addition to volatile oil, the seed also contains about 10% of fixed greenish brown oil with a strong aromatic flavour. It is semi-drying oil with an iodine value of 92. Cumin oleoresin is also obtained from the seeds.

Value Added Products:

The value added products are cuminpowder, cuminoil and cumin oleoresin.

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DILL SEED

Scientific Name : *Anethum graveolens* L
Family : *Apiaceae/Umbelliferae*
English name : Dill, Garden Dill, Anet
Indian name : *Sowa, Soya* (Hindi, Bengali, Punjabi and Urdu); *Surva* (Gujarati), *Sabasige* (Kannada), *Soi* (Kashmiri), *Surva, Shepu* (Marathi), *Satapushpi* (Sanskrit), *Sathakuppi Sompa* (Tamil), *Sabasige* (Telugu)

Dill was known as a garden plant in ancient literature and the use of fruits as condiment was known since biblical times. Dill is of value for both its leaves and seeds. Leaves are also known as Dill weed‘, fresh or dried. When fresh, the leaves have a pleasant aromatic odour and warm taste. Dill seed with its pleasantly aromatic and warming flavor, laced by woody and menthol notes, is excellent for flavouring and seasoning.

The genera *Anethum,* in which there are two species under cultivation, namely, The European dill, *A.graveolens* L. and another closely related Indian dill, *A. sowa* Roxb. ex Flem. Indian dill yields 1.2 to 4.0% volatile oil while European dill grown under Indian conditions yields 2.5 to 4.0% oil. The major constituent of seed oil is carvone (19.5 to 69.7%). Carvone content is the highest in European dill. The sowa herb yields 0.06% of essential oil, which has a higher proportion of terpenes (a-phellandrene), but no carvone. European dill herb oil contains both carvone and a-phellandrene. Badoc and Lamarti (1991) identified three broad chemotypes of European dill by the presence of carvone, and the presence or absence of myristicin and dillapiole.

Uses

Dill seeds are used, both whole and ground, as a condiment in soups, saiads, processed meats, sausages, spicy table sauces and in dill pickling. Dill stems and blossom heads are used for dill pickling and for flavouring soups. Grounds seed is an ingredient of seasoning. The green herb is used as a flavouring agent.Both seeds and oil (mainly) are used in the preparation of various

CORIANDER

Scientific Name : *Coriandrum sativum* L.
Family : Umbelliferae / Apiaceae
English name :Coriander
Indian name : Dhania, Dhanya (Hindi), Kothambri, Kothamiri bija (Kannada), Kothumpalari bija (Malayalam), Dhanyaka (Sanskrit), Kothamalli(Tamil), Dhaniyalu (Telugu).

Coriander of commerce is the dried fruit of *Coriandrum satiuum* L., an aromatic spice crop. It is a very old flavouring substance and its usage both for its leaves, stems as well as fruits has been mentioned in Egyptian, Herbrew and Roman literature as early as 5000 BC. The essential oil content of the seeds is about 0.1-0.7%. The seeds also contain 19-21% fatty oil, which solidifies upon keeping and is used in the manufacture of sodium soaps and has a pleasant odour. The residue left after extraction of volatile oil is used in cattle feed.

Economic uses:

- All parts of the plant are indispensable food adjuncts in Indian cookery.
- Coriander fruits serve as a common flavouring substance for both sweet and savory dishes, especially in Europe and India.
- The fruits are often candied in a sugar solution and sold as sugar plums.
- In the USA and Europe it is used for flavouring spirits and gin.
- Oil of coriander is used in medicines and flavoring beverages, such as gin, whisky and various liquors.
- Coriander seeds are used for the preparation of mouth freshener.
- The dried fruits are an important ingredient of curry powder, sausages and pickling spices.

Medicinal properties and uses:-

- Coriander fruit is a highly aromatic, stimulant, carminative and antispasmodic.
- The fruits are used in infusion or decoction.
- The seeds are generally chewed to vanish bad smell breath created due to consumption of garlic.
- The roasted seeds are useful in dyspepsia. The juice of fresh plant is applied in erythema.
- The paste made from seed is useful in pain in cephalagia.
- The decoction with milk and sugar is beneficial during bleeding piles.
- The infusion or powder of fried seeds is very useful in colics of children.
- Coriander reduces intoxicating effects of spirituous liquors.
- It is not advisable to take the coriander essential oil internally.
- The active principle of the coriander is Linolool.

Origin and distribution

Among the genus *coriandrum*, the annual aromatic herb of *Coriandrum satiuum* is widely cultivated in India for its spicy fruits. The plant is considered to be a native of the Eastern Mediterranean region or Southern Europe. Precisely, Italy is presumed to be the native place of coriander.

It is extensively cultivated in Morocco, Romania, India, France, Spain, Italy, the former USSR, Holland, Yugoslavia, Pakistan, Turkey, Mexico, Hungary, Poland, Argentina, Guatemala and to some extent in England and the USA. In India it is widely cultivated in Rajasthan, Gujarat, Andhra Pradesh, Bihar, Karnataka, Maharashtra, Madhya Pradesh, West Bengal and Tamil Nadu.

In Karnataka, the crop is cultivated in the districts of Darwar, Bijapur, Bagalkot, Chithradurga, Chikkamagalore and Belgaum.

In Gujarat, it is cultivated in Mehsana and Banaskantha. Coriander is generally grown surrounding the big cities to meet the requirement of green leaves locally known as kothmir.

Area and production

In India, it is cultivated practically in all the states with a total production of 2,36 lakh tonnes of seeds over an area of 3.6 lakh hectares. Rajasthan stands first both in area as well as in production, followed by Andhra Pradesh, Tamil Nadu and Madhya Pradesh. Karnataka stands fifth with a production of 20,864 tonnes from an area of 12875 ha.

Climate

Coriander is a tropical crop and can be successfully cultivated in the rabi season in areas that are free from severe frost during the flowering and seed setting stages. Dry and cold weather favours higher seed production. Cloudy weather during the flowering and fruiting stages increases pest and disease incidence.

The time of sowing however varies in different locations in India. In West Bengal and Uttar Pradesh, the seeds are sown during the rabi season, in Maharashtra during the kharif, in Tamil Nadu in the kharif and rabi, in Karnataka from May to August and from October to January and in Gujarat in first week of November.

Soil

Coriander is cultivated both as an irrigated and rain-fed crop. As an irrigated crop, coriander can be cultivated on almost all types of soils, provided sufficient organic manure isapplied. A rain-fed crop may be raised only on the heavier types of soil which have better water-holding capacity. The crop is best cultivated on heavy black, clayey cotton soils and rich silt loams which are well drained with distributed moisture. Saline, alkaline and sandy soils are not suitable for this crop.

Varieties

A number of cultivars, distinguished by the name of the locality, are under cultivation. The yield varies depending on variety and location. The varieties are grouped as the bold and small seeded types. The important cultivars developed from different organization are given below:

Varieties developed from Rajasthan Agricultural University.

1) RCr-41

It is a selection from local collection of Kota and released in 1988 for irrigated conditions. The plants are tall, erect with small-sized (9.3g/1,000) grains. The cultivar is highly resistant to stem gall and wilt but only moderately tolerant to powdery mildew. It matures in 130-140 days and produces an average yield of 9.2 q/ha.

2) Rcr-20

It is selection from local collection of Jaipur and released in 1997 for limited moisture conditions and the heavier soils of southern Rajasthan. The plants are bushy, spreading, with a medium height. It produces oval grains of large size (18.0g/1,000). It is moderately tolerant to powdery mildew, wilt as well as stem gall. The cultivar matures in 100-110 days and produces an average yield of 10.0q/ha.

3) RCr-435

It is selection from local collection of Jalore district and identified for release in 1995 for irrigated conditions. The plants are bushy with a quick, early growth and medium-sized grains (14.0 g/ 1,000). It matures in 110-130 days and produces an average yield of 10.5 q/ha.

4) RCr-436

It is selection from local collection of Kota and identified for release in 1995 for limited

moisture conditions. The plants are bushy with quick early growth and bold grains (16.0 g/1,000). It matures in 90-100 days and produces an average yield of 11.09 q/ha underlimited moisture conditions.

5) RCr-446

It is selection from local collection of Jaipur district and identified for release in 1977 for irrigated conditions. The plants are leafy and erect with higher number of grains per umbel. The seeds of this variety are medium in size (13.5 g/1000). It matures in 110-130 days and produces an average yield of 12 q/ha.

6) UD-20

It is selection from the Jaipur local developed during 1983 for rain-fed conditions. The plants are tall, erect with oblong, bold grains (13.5 g/1000). It matures in 110 days and produces an average yield of 12 q/ha. The variety is resistant to wilt and stem gall diseases.

Varieties developed from Gujarath Agricultural University:

1) GC-1

It is selection in local material and released in 1974 for early sowing conditions. The plant is erect with medium sized (13.2 g/1,000 grains) and round, yellow-coloured grains. It is moderately tolerant to wilt and powdery mildew. It matures in 112 days and produces an average yield of 11.61 q/ha.

2) GC-2

It is selections from Co-1 and released in 1985, for early sowing. The plants are of a semi-spreading habit, and have dense foliage with dark green leaves and bold grains (14.8g/1,000 grains). It is moderately tolerant to wilt and powdery mildew. It matures in 110 days and produces an average yield of 14.02 q/ha.

3) Gujrat Dantiwada Leafy Coriender-1

GDLC-1 is released from main seed spices research station, SDAU, Jagudan (Gujarat) particularly for leaf purpose. It has dark green, broad leaves with more numbers of tillers.

Varieties developed from Andhra Pradesh Agricultural University:

1) CS-4 (Sadhna)

It is selection from the Nandyal collection and released in 1989 for rain-fed and late-sown conditions. The plants are semi-erect with medium-sized (16.8g/1,000 grains), oval, strawcoloured grains. The cultivar is tolerant to white fly and mites. It matures in 100 days and produces an average yield of 10.3 q/ha.

2) CS-6 (Swathi)

It is selection from the Nandyal collection and released in 1989 for rain-fed and late sown conditions. The plants are semi-erect with medium-sized (16.8g/1,000 grains), oval, brownish-yellow grains. The cultivar is tolerant to white fly, grain mould and wilt, and produces an average yield of 8.8 q/ha.

3) CS-2 (Sindhu)

It is selection from Warrangal local and released in 1991 for rainfed conditions. The Plants are dwarf with medium sized (16.5 g/1,000 grains), oval, straw coloured grains. The cultivar is tolerant to wilt and powdery mildew and resistant to aphids. It matures in 102 days and produces an average yield of 10.5 g/ha.

Varieties developed from Tamilnadu Agricultural University:

1) CO-1

It is selection and released in 1972 for the rain-fed conditions of the southern districts of Tamil Nadu. The plants are small with globular, small (14.3 g/1,000), dusty brown grains. It matures in 100-120 days and produces an average yield of 4.0 q/ha.

2) CO-2

It is selection from P2 cultivar of Gujarat and released in 1985. It is a dual-purpose cultivar suited for use as greens and for the production of grains. It can be grown in water-logged, drought, saline and alkaline conditions. The plants are erect, with oblong, medium-sized (15.0 g/ 1,000 grains), dull yellowish-brown grains. It matures in 90-110 days and gives green leaves in 40 days and produces an average grain yield of 5.2 q/ha and green yield of 100 q/ha.

3) CO-3

It is selection from ACC 695 of IARI and released in 1991 for irrigated and rain-fed conditions. The plants are dwarf with medium-sized (16.2 gI1,000), oblong, brownish-yellow grains. It is tolerant to wilt, powdery mildew and grain mould. It matures in 86-104 days and produces an average yield of 6.5 q/ha.

4) CS-287

It is selection from CS-6 and released in 1991 to irrigated and rain-fed conditions. The plants are early maturing with medium-sized (14.9 g/ 1000 grains), oblong, straw-yellow coloured grains. It is tolerant to wilt and grain mould. It matures in 78-97 days and producesan average yield of 6.0 q/ha.

Variety developed from Rajendra Agricultural University, Bihar:

1) RD-44 (Rajendra Swathi)

It is selection from the Muzaffarpur Local and released in 1987. The plants are medium-sized with fine, round, aromatic grains (12.5 g/ 1000 grains). It is resistant to stem gall and moderately resistant to wilt, aphid and weevil. It matures in 100 days and produces an average yield of 13 q/ha.

Variety developed from Harayana Agricultural University:

1) DH-5

It is selection from a local collection and identified in 1993, for irrigated conditions. The plants are medium-tall, bushy with round attractive grains of medium-size (13.8 g/1000). It matures in 120-130 days and produces an average yield of 18-20 q/ha under good management.

Variety developed from Central institute of Medicinal and Aromatic crops, Bangalore:

1) CIMPO, S-33

It is selection at the Central Institute of Medicinal and Aromatic Crops, Bangalore from the Bulgarian introduction. The variety is a tall, late-maturing type with small seeds and can yield 21 q/ha of seeds (three times more) compared to 7.5 q/ha from the local cultivars. It has an oil content of 1.3% as against 0.18% of the local, giving 27.5 2 kg/ha of oil which is seven times more compared with the local variety.

The other important cultivars are CS-15, CS-362, CS-52, CS-7, CS-11, CS-358 Rcr-648, Hissar Anand, Pant Haritima, Azad Dhania, DWD-3, Gwalior 5365, V1, V2, Naranul Selection, NP (D) 95, NP (D) 172, NP (K) 24, Amber and Pusa selection 360.

Varieties for seed purpose:

CS 2, MS 1, MS3, CS, 3 CS 4, CS 6, RCI, Karan (UD 41), UD 1, UD 2, UD 20, UD 21, GAU 1, CIMPOS 33, CIMAPS 20, S 15 and S 33.

Varieties for dual purpose

CS 5, Co 1, Co 2, IARI S 360, IARI Seethal 36-3, CIMPOS 28, and CIMPOS 52.

Propagation

Coriander is propagated by seed. Before sowing the fruits are rubbed until the two mesocarps are separated and then it is sown.

Land preparation and sowing

The land should be well prepared by ploughing 3 to 4 times and brought to a fine tilth. For

an irrigated crop, beds and channels of convenient size (3 x 2 m) are formed. The seed rate requirement in coriander varies from 10-15 kg for irrigated and 25-30 kg per hectare for rain-fed crops. The seeds that are stored for 15-30 days exhibit an early and better germination.

At the time of sowing, the seeds are trampled or crushed into halves with the foot or by rubbing with hands. The seeds are then treated with Agrosan-GN or any other mercurial fungicide or Carbendazim at 2 g per kg of seeds.

Sowing is done either by broadcasting or by drills in rows at 20-30 x 10 cm spacing. The seeding depth should not exceed 3.0 cm. The broadcasted seeds are raked up to mix them with the soil.

Soaking the seeds in cold water for 12-24 hours can also be done to hasten the germination process before sowing. Soaking seeds in a solution of 50 ppm Gibberellic Acid is beneficial. Seeds soaked in 1% Potassium dihydrogen phosphate solution or in 2% leaf extract of Calotropis and Prosopis registered an improved germination and seedling growth especially in the rain-fed crop.

The seed germination is rather slow and may take 10-15 days. The thinning of plants is done after 30 days of sowing leaving only two plants per hill.

Manures and fertilizers

About 10-20 tonnes of FYM per hectare should be applied to the field well before planting. Fertilisers @ 40:40:40 or 30:40:20 kg or 15:40:20 or 35:35:35 or 20:30:20 NPK per hectare are applied depending on the location at the time of sowing. The recommendation is based on the research conducted at different locations. Nitrogen is applied in 2 split doses. The first dose is given at the time of sowing and the next one is applied after 6 weeks of sowing. For a rain-fed crop, an application of 20 kg Nitrogen per hectare is sufficient. A foliar application of Cu, Zn and Mo is reported to increase the seed yield. Application of 10-15 tons of well rotten FYM and NPK @ 20, 10 and 00 kg/ha respectively are recommended for Gujarat conditions. The application of half dose of nitrogen and full dose of phosphorus is given at time of sowing and remain half dose of nitrogen is given at 30 days of sowing.

Irrigation

The crop is irrigated immediately after sowing in order to ensure even germination, and later irrigation is provided at 7-10 days intervals, depending upon the soil and climatic conditions. The crop requires in all 4-5 irrigations, 30-35, 60-70, 80-90, 100-105 and 110-150 days after sowing.

Inter-culture

The crop requires two or three weedings. The first weeding, hoeing and earthing-up should be done at 40-45 days after sowing, when the seedlings are well above the ground.

Weeds can be checked by the application of Pendimethalin or Fluchloralin @ 1.5 kg or 5-6 kg Propanil per hectare alone or in combination as pre-emergent and post-emergent weedicides, which can bring about the optimum control of weeds with a considerable increase in seed yield. Hoeing is done to conserve the soil moisture for better yields. A spray of 250 ppm Cycocel (CCC) one month after sowing is beneficial for the rain-fed crop. The companion cropping of coriander plus mustard has been found to be economical.

Use of growth regulators

A spray of GA_3 100 ppm at the five-leaf stage increases the male flowers, while Ethrel and CCC reduce the ratio of bisexual and male flowers. GA_3 from 5 ppm upto 50 ppm hastens and improves flowering, when sprayed at the five-leaf stage; BA counters the effect of GA. Soaking the seeds in 50 ppm IAA improves flowering, while ascorbic acid increases the frequency of bisexual flowers. The application of Magnesium chlorate at 8 kg/ha at the waxy stage of ripening makes harvesting easier and improves the essential oil content.

Harvesting

The coriander plant matures in 90-120 days for grains and 40 days for greens. Leaf plucking, to the extent of 50%, when the crop is 60- 75 days old gives economic returns, under irrigated conditions. The crop should not be allowed to turn over ripe as this will spoil the quality, particularly the colour of the produce. The kharif season crop matures earlier than the rabi season crop. Harvesting has to be done when the fruits or 50% of seeds are fully ripe and start changing from green to brown colour.

High yields could be obtained when the plants are harvested at the stage where 100% of the fruits turn yellow. For harvesting, plants can either be uprooted or cut back using sickles. The plants are then tied in small bundles andstacked for drying.When the bundles are dried, the grains are separated by beating them gently against the threshing floor. The grains are winnowed and stored in a moisture-free godown, till they are sold. The moisture content should be moderate as the quality will decrease with excess moisture.

Yield

On an average, a seed yield of 400 to 500 kg/ha under rain-fed conditions and 1000 to 1250 kg/ha under irrigated conditions may be obtained. Under favourable conditions, yields of 1700 kg to 2240 kg/ha have been recorded.

Storage of seeds

The whole, dried seeds are usually packed into sacks and stored in a cool, dry room. At the time of storage the seeds should not contain more than 0.5 to 9% moisture. It is reported that no more than 5% volatile oil would be lost during two year storage period. It has been recommended that the spice should be placed in hermetically-sealed cans immediately after drying, in order to ensure that quality deterioration during storage is minimal. The crushed or ground spice should be stored in air-tight containers. The spice entering international trade varies considerably in its physical and chemical characteristics according to the geographical source, and consequently, some users express preferences for certain types in particular applications.

In commerce, coriander is broadly divided into two types according to the size of the fruit, which is an indication of its volatile-oil content and suitability for particular end-uses, as the var. uulgare (diameter 3- 5 mm) or the var. microcarpum (diameter 1.5-3 mm). The large fruited types supplied mainly by tropical and subtropical producing countries, e.g., Morocco and India, contain low volatile-oil content (0.1-0.35%) and are used extensively for grinding and blending purposes.

The smaller-fruited types are produced in temperate regions and usually have a volatile-oil content of more than 0.4%. The very small-fruited types grown in the USSR and some other countries of Eastern and Central Europe contain between 0.8 and 1.8% volatile oil and are highly valued as a raw material for the preparation of essential oil.

Extraction of essential oil and adulterants

Commercial coriander oil is prepared by steam distillation of the mature, dried fruits. The yield of the essential oil obtained varies from 0.88 to 0.92%. The commercial volatile oil is extensively adulterated with sweet orange oil, turpentine or aniseed oil or cedar wood oil.

Value-added products

The oil of the coriander grains is a valuable ingredient in perfumes. Its soft, pleasant and slightly spicy note blends into scents of oriental character. Decydenyde (0.1% volatile oil) is also used in perfumery.

Good quality oleoresin is extracted from coriander seeds. The oleoresin is used for flavouring beverages, pickles and sweets. Soluble coriander is prepared by properly blending and dispensing a minimum of 3% of the total extractives of coriander on a soluble, dry, edible carrier.

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FENNEL

Scientific Name :*Foeniculum vulgare*L.
Family :Apiaceae
English name :Fennel
Indian names :Saunf, Sonp (Hindi), Pan, Muhiri, Mauri (Bengali), Variari (Gujarati), Badi sompu (Kannada), Perum-jeerakam (Malayalam), Badishep (Marathi), Saunf (Punjabi), Madhurika (Sanskrit), Shombei (Tamil), Sopu, Pedda-jilakara (Telugu)

Fennel commonly known as *Saunf* or *Badi saunf.* Itis cultivated mainly for its seeds from which the spice oil is obtained. The main constituent of the oil from the fruits is anethole. Fennel oil of good quality contains 50-60% transanethole. Indian fennel oil contains over 70% anethole and 6% fenchone.

The plant is pleasantly aromatic and is used as a pot herb. The leaves are used in fish sauces and for garnishing. The leaf stalks are used in salads. Medicinally, the leaves are regarded to have diuretic properties while the roots are purgative. The dried fruits are extensively used for flavouring soups, meat dishes and sauces, bread rolls, pastries and confectionery. They are also used for flavouring liquors and pickles. The fruits are aromatic, stimulant and carminative; they are considered useful in treating diseases of the chest, spleen and kidney. They are also employed as a corrective for less pleasant drugs, particularly senna and rhubarb.

The plant is pleasantly aromatic and is used as a pot-herb. Leaves are used in fish sauce and for garnishing; leaf stalks are used in salad. The dried fruits are used as amasticatory or for chewing alone or in pans. They are also used as a flavouring agent. The fruits are aromatic, stimulant and carminative and are considered useful in diseases of the chest, spleen and kidney. Leaves are reported to have diuretic properties. The residue left after the distillation of essential oil from the fruit is used as cattle feed.

Fennel oil is largely used as a flavouring agent in culinary preparations, confectionery, cordials and liquours. It is useful in infantile colic and flatulence. It also checks griping in purgatives and is used as a germicide against hookworms. It is also used in scenting soaps in addition to perfumery. The residue left over after the distillation of the essential oil from the seeds is used as feed for cattle. The seed contains 14-22% proteins and 12-16% fat.

Origin and distribution

The plant is a native of Southern Europe, Asia and Africa. It is widely cultivated throughout the temperate and subtropical regions of the world, particularly in France, Italy, Bulgaria, Morocco and Spain for its aromatic fruits used as a culinary spice, and the extraction of essential oil. In India, it is mainly grown as a garden crop or as a small-scale crop during the winter, mainly in the states of Rajasthan, Maharashtra and Gujharat and also in some parts of Punjab, Uttar Pradesh, Madhya Pradesh, Haryana and Andhra Pradesh. In Karnataka, it is grown on a small scale in Belgaum and Dharwad districts.

Area and Production

The area under this crop is reported to be about 50,000 hectare and production around 56,000 tonnes. In spite of having a number of industrial and medicinal uses, and a good foreign exchange earner, at present the crop is not being exploited commercially. The major types of fennel in the world market are Indian fennel, Egyptian fennel and Chinese fennel.

Climate

It is cultivated throughout India at altitudes upto 2000 m. It requires a fairly mild climate and is cultivated as a cold weather crop in parts of North India. It does not succeed so well in South India, except at high elevations.

Soil

Fennel grows in any good soil, but thrives best in rich, well-drained loam or black sandy soil containing sufficient lime. Any soil which has a high salt content in it and is prone to water-logging is unsuitable for its cultivation.

Varieties/cultivars

There are a large number of varieties and races differing in size, odour and taste of the fruits, and they are hardly distinguishable from one another.

Improved cultivars identified and released for cultivation are:

Varieties developed from Rajasthan Agricultural University:

1) RF-101

It is selection from a local collection of Tonk and indentified for release in 1995. The plants are tall, erect with stout stem. It bears large umbels with longs bold grains. It matures in 150-160 days and produces an average yield of 15.5 q/ha.

2) RF-125:

It is selection from an exotic collection, EC-243380 from Italy, and identified for release in 1997. The plants are early, short, with compact umbels and long bold grains. When green, they present a denser view. It matures in 110-130 days and produces an average yield of 17.3 q/ha.

Varieties developed from Gujarat Agricultural University:

1) PF-35:

It is selection from local germplasm and released in 1973. The plants are tall and spreading with medium-sized, hairless and green seeds. It is moderately tolerant to sugary disease, leaf spot and leaf blight. It matures in 225 days and produces on average, yield of 12.8 q/ha.

2) Gujarat Fennel-1:

It is selection from Vijapur local and released in 1985. The plants are tall and bushy with oblong, medium bold and dark green seeds. It is moderately tolerant to sugary disease and leaf mud. It matures in 225 days and produces an average yield of 16.95 q/ha. It is good for early sowing and reasonably tolerant to drought.

3) S-7-9:

It is a dwarf selection yield about 1000 kg/ha.

4) Other recent varieties from SDAU:

Gujarat funnel-2, Gujarat funnel-11and Gujarat funnel-12 are recently released varieties having the yield of 2219, 2489 and 2588 kg/ha, respectively. All these varieties are mature in 150-160 days.

Variety developed from Tamilnadu Agricultural University:

1) Co-1

It is selection from IARI and released during 1985. The plants are medium in height with diffuse branching. It matures in 220 days and produces an average yield of 5.67 q/ha. It is suitable for drought-prone, waterlogged, saline and alkaline conditions. It is suitable for hilly areas as well as for intercropping and boarder cropping.

Cultivation

Propagation

It is propagated easily by seeds, but can also be grown by root or corm divisions. The seeds are broadcasted or line-sown by shallow drills. Soaking seeds prior to sowing improves germination. The seeds can be sown in a nursery bed and later the seedlings are transplanted to the field when they attain 8-10 cm height. For transplanted crop, seeds are sown in the nursery during

the months of May-June and seedling of 1.5 – 2.0 months are transplanted in the main field in August-September.

Land preparation and sowing:

The field is brought to a fine tilth by continuous ploughing and laid out into beds of convenient size along with the irrigation channels. It is manured with 25 tonnes of FYM along with the basal dose of nitrogen, phosphorus and potash. The seeds are either broadcasted or drilled in rows at a 45-60 cm spacing for rain-fed and 40-80 cm apart for irrigated crops. About 8-10 kg seeds per hectare are required for drilling and 3-4 kg/ha for transplanted crop. When the seedlings are 8-10 cm in height they are thinned in rows at 10 cm in the rain-fed and 40-45 cm in irrigated crop.

Sowing

The time of sowing is during October-November in the plains and March-April on hills. Under Gujarat conditions, the crop can be grown as a winter season crop during the months of last week of October to first week of November.

Manures and fertilizers

The FYM @ 15-20 tonnes per hectare to be applied at the time of land preparation. The NPK dose of 27-60 kg N, 12-40 kg P205 and 21 kg K_2O /ha is recommended. For Gujarat conditions, the application of 45 kg of N, 30 kg P_2O_5 and 45 kg of K_2O results in good seed and oil yield. Of this, half of the nitrogen and the entire quantity of phosphate and potash are applied as a basal dose while the remaining half of the nitrogen is given in two equal split as a top-dressing at 30 and 60 days after sowing. The application of micronutrient zinc (0.3%) and boron (0.1%) as foliar spray has been recommended.

Irrigation

The field is irrigated immediately after seeding if there are no rains. Initially, the irrigation upto one month is given at 3-4 day intervals and thereafter at weekly or 15-20 day intervals has been found to improve the yield considerably.

Inter-culture

As the crop is delicate, frequent weedings at initial stages of growth is essential. Subsequent weedings may vary with the situation. About 3- 4 weedings may be enough for the entire life cycle of the crop. A pre-emergence application of Pendimethalin @ 1.0 kg/ha with one hand weeding 50 days after sowing controls the weeds effectively.

Inter-cropping

Intercropping fennel plus radish is found to be remunerative. Fennel is also grown as a mixed or inter-crop with chilli.

Physiological disorder

Sugary Secretion

It is a physiological disorder, due to which flowers secrete sugary substance; attracting fungus from outside. Due to this disorder, quality and production of crop is affected. This phenomenon is observed in those plots which have been highly manured and irrigated under heavy dewfall and cold condition. Sugary secretion spreads on flower parts, stem etc. Due to this mold and other fungus develop on plants causing black and gummy appearance. The sugary secretion attracts aphids too and these insects attack the plants. Combined effect of above gives false appearance of disease, but really sugary secretion is not a disease.

For the control of this disorder,

1. Stop irrigation and manuring, Spraying of 0.03% solution of Dimethoate or 0.05 % solution of Phosphamidone or any systemic pesticide should be done to control the aphids.

2. Fennel is most vulnerable to frost damage at the flowering and early seed formation stage. The frost damage can be minimized by spraying 0.1% sulphuric acid solution. Irrigating the crop prior to the incidence of frost using wind breaks and creating smoke cover in the early morning.

Harvesting and yield

The crop is harvested after 5-6 months of sowing, before the fruits are fully ripe, to avoid shattering. The umbels are harvested at 'half length size of grain yet green stage'. For the production of the chewing type, the crop can be harvested when the grains are at half length size (around 30 days after anthesis). While harvesting, the stems are cut with a sickle and spread out in loose bundles to dry in the sun. The dried fruits (after 4-5 days) are threshed and cleaned by winnowing.

The per hectare seed yield in fennel ranges from 20-25 quintals which, in turn, may yield about 35-40 kg of essential oil under irrigated conditions. The dried and cleaned seeds should be stored in jute bags in damp-free, aerated stores. The seeds are cleaned with the help of a vacuum gravity separator and stored in an aerated store. The fennel fruits (seeds as they are known in commerce) are classified for trade purpose according to their place of origin. Some of the well-known types in India are Bombay, Bihar and Uttar Pradesh. The fennel seeds from Lucknow are considered to be the best for culinary purposes and are higher priced than those from other areas.

Postharvest technology

Drying of Fennel Seeds

Harvested umbels are dried in sun for 1–2 days and then in shade for 8–10 days. Care must be taken not to sun-dry the umbels too long as long exposure of seeds to the sun reduces the quality of the produce.

Cleaning and Grading

After drying, fennel seeds are cleaned with the help of vacuum gravity separator or spiral gravity separator. Cleaned seeds are then graded based on its quality and then packed in jute bags for marketing. 10 days intervals. 0.1% solution of sulphuric acid prior Storage.

Storage:

Dried and clean seeds are stored in jute bags in damp-free aerated store.

Distillation of Oil

To obtain the maximum oil, the fruits are crushed before distillation. The oil obtained from fruits by steam distillation is a pale yellow-coloured liquid with a characteristic taste and odour. Two types of oil are recognised in commerce: (i) Sweet fennel oil from the fruits of var., dulce, and (ii) Bitter fennel oil from the fruits of var., vulgare.

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LECTURE 1
PLANTATION CROPS

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

Definition in traditional sense – Plantation crops are those which are cultivated on extensive scale like tea, coffee and rubber. Here the term plantation or estate is used synonymously. **Estate or plantation means large scale agricultural unit usually of a single crop.**

Differences between plantation crops vs. fruit crops:

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

Important plantation crops

- Oil yielding crops:Coconut, oilpalm, palmyrah

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

Status of plantation Crops in India

1. **Area and distribution**: Plantation crops have limited geographical distribution and in the world it is largely grown between 20^0N and 20^0S of equator.

Area and production of Plantation crops in India 2009-11

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

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

Area and production (Crop wise)

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

Rubber	**A**	**578**	**P**	**980.0**
Oilpalm	**A**	**171.7**		
Total				

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

Area occupied by plantation crops in India = 4 million ha.
=2.8% of total cropped area.
Earnings from export of plantation crops is 27% of total agricultural . Commodities and 4.8% of total export.

2. Topographical situation of plantation crop area in India:

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

3. **Commercialization of plantations:**

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

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

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

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

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

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

Question Bank :

1)Define Plantation crop and differentiate between plantation and fruit crops ?

2)Growing of more than one annual or perennial crop in the interspace of main crop is termed as ---------- (Multiple cropping)

3) Plantation crops are mainly grown for export market . Justify ?

4) Plantation crops are grown mainly in South India . Why ?

5) List out the important beverage crops with botanical name and family ?

LECTURE 2

Scope and Economic importance of plantation crops

Scope for plantation crops:

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

2. Export potential: Plantation crops earn foreign exchange.

Eg. Coir based products ,Coir export and Coffee .

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

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

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

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

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

Eg. CPCRI Kasargod, Kerala.

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

Economic importance of plantation crops:

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

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

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

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

Eg: Tea- 20 lakhs people-

Cashew-5 lakhs people

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

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

5. Conserving soil and ecosystem:

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

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

Important Research Stations on Plantation and Beverage Crops

Coconut : Central Plantation Crop Reserch Institute , Kasargode, Kerala

Arecanut : CPCRI, Regional Research Station, Vittal, Karnataka

Cocoa - CPCRI, Regional Research Station, Vittal, Karnataka

Rubber: Rubber Research Institute of India, Kottayam, Kerala

Cashew : Directorate of Cashew Research, Puttur, Karnataka

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

Palmyrah : Srivaliputtur, Tamil Nadu

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

Coffee : Central Coffee Research Institute, Balehonnur, Karnataka

Question Bank .

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

Coconut

Coconut (*Cocos nucifera* L.)

Family: Palmae

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

Origin and distribution: Origin - South East Asia.

Distribution of coconut

World:

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

India:

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

Botany

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

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

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

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

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

Climate and soil

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

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

Cultivars and hybrids

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

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

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

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

The common dwarfs available in India are

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

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

Hybrids

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

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

    Special feature

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

Special feature

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

Selection of mother palm

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

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

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

Preparation of land and planting

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

Spacing

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

Care of young palms

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

Manuring

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

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

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

TNAU Coconut tonic

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

Bio-fertilizer recommendation

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

Organic recycling

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

Irrigation

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

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

Inter cultivation

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

Inter and mixed cropping

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

Harvesting

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

Yield

60-80 nuts per palm per year

Special Problem

Shedding of buttons and immature nuts and production of barren nuts

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

Production of barren nuts

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

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

Plant protection

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

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

Value added Product

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

HORTICULTURAL DATABASE, 2010)

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

Coconut milk powder

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

Coconut syrup

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

Coconut honey

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

Desiccated coconut

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

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

Coconut flour

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

Dietary fibre

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

Toddy Products

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

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

Virgin coconut oil

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

Coir and coconut fibre

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

White fibre

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

Production is mainly confined to Kerala.

Brown fibre

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

Coir pith or dust

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

Coconut shell-based products

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

Arecanut (*Areca catechu)*

Arecacaae (Palmae)

Origin: Malaya, Phillipines, East Indies

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

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

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

Uses:

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

Botany:

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

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

Cultivars: Mangala, Sumangala, Sreemangala.

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

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

Sree mangala- compact bunches with bold and round nuts.

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

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

Other varieties:

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

Soil: Deep, well-drained soil.

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

Propagation: Seeds

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

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

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

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

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

Spacing: 2.7X 2.7m

Fertilizers: NPK 100: 40: 140kg/ha

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

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

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

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

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

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

Processing:

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

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

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

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

Types (Based on cuts and shapes)

Api or Unde - Processed without cutting

Batlu- Cut transversly into two halves

Choor- Several longitudinal cuttings

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

Scented supari:

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

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

Fruit rot (Koleroga/ Mahali)

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

Bud rot:

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

Foot rot or Anabe:

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

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

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

Soil and climate

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

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

Season

June – December is found to be the optimum.

Sowing

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

Planting

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

Irrigation

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

Manuring

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

After cultivation

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

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

Pests

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

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

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

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

Diseases

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

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

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

Yellow Leaf Disease

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

Leaf spot

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

Nut crack

Spray Borax 2 g/lit with proper water management

Harvest

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

Yield

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

Cashew (*Anacardium occidentale*)

Native of Brazil

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

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

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

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

India exports cashew kernels to over 60 countries

US is the largest market for Indian cashew kernels

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

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

USES:

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

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

MAJOR CASHEW GROWING DISTRICTS IN TAMIL NADU

Cuddalore, Pudukottai, Ariyalur, Sivagangai and Theni Varieties:

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

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

Important Varieties and their special characters

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

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

Soil and climate

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

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

Cashew is an hardy crop.

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

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

Propagation in cashew

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

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

Grafting: Epicotyl / Soft wood

Production of scion sticks

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

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

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

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

Variety of scion and precuring

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

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

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

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

Collection of scion stick

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

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

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

Raising of root stock seedlings:

Selection of seednuts

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

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

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

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

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

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

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

Maintenance of seedlings in the nursery

Daily watering is required during summer season.

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

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

Soft wood grafting technique: Preparation of root stock

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

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

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

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

Preparation of scion

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

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

Grafting

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

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

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

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

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

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

Spacing: 7 m either way

200 plants/ha can be planted.

Preparation of field

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

High Density Planting

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

Manuring :

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

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

Intercropping

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

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

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

Rejuvenation of old cashew orchard by top working

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

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

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

Advantages of top working

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

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

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

We can have different varieties of cashew on a single tree

Harvest

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

Yield

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

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

The processing of raw nuts involves

Roasting, shelling, drying, peeling, grading and packing

PROCESSING OF CASHEWNUT

Drum roasting

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

Steam roasting

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

Oil bath roasting

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

Steam roasting

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

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

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

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

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

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

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

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

Grading

Kernels are graded according to the size manually.

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

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

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

Packaging

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

Composition of kernels:

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

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

COCOA Theobroma cacao Malvaceae

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

Origin and distribution

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

Percentage nutritive value of cocoa and chocolate

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

There are two major varietal types in cocoa

Criollo and Forastero

Forastero types are known to perform well under Indian conditions.

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

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

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

Refer Practical manual

COFFEE

Botanical name: *Coffea sp*.

Family: Rubiaceae

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

Origin: Ethiopia and Africa.

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

World: 10.55m ha, 7.7 mill.T

India: 3.2 lakh ha, 2.7mill.T

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

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

Species and cultivars (50-60 in the genus)

Four/ Five species contribute to commercial coffee

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

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

Distinguishing features:

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

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

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

Varieties:

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

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

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

Low % of defective beans

Yield 2000kg/ha.

Sel.7 (San Raman hybrid)

San Raman is a dwarf mutant of Arabica.

San Raman X S.795 ➐7.1

S.7.2 X HDT (Hibrido –da Timor)

↓

5.7.3 - suitable for close planting.

Yield 1500kg/ha, drought tolerant.

Sel.8 (HDT)

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

Sel.9:

HDT X Tafarikela (Arabica)

↓

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

Sel.12: Cauvery/ Catimor

Caturra X HDT semi- dwarf hybrid.

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

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

Karnataka: Chickmaglur, Mudigere, S.coorg.

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

Botany:

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

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

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

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

Bean defects:

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

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

Location:

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

Spacing:

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

Dwarf – 5' X 5'

Robusta – 10' X 10' / 12' X 12'

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

- Pitz- 45cm3 during Mar-Apr

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

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

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

Training:

Gives frame work and proper shape to the plant.

1. single stem
2. Multiple stem are followed.

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

Arabica tall- 2.5 ft

Dwarf- 3-4.5 ft.

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

Multiple stem: It is easy and cheaper.

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

Pruning:

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

Rejuvenation:

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

Harvesting:

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

Types of picking:

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

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

in Brazil, mechanical harvest is also practiced.

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

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

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

Drying

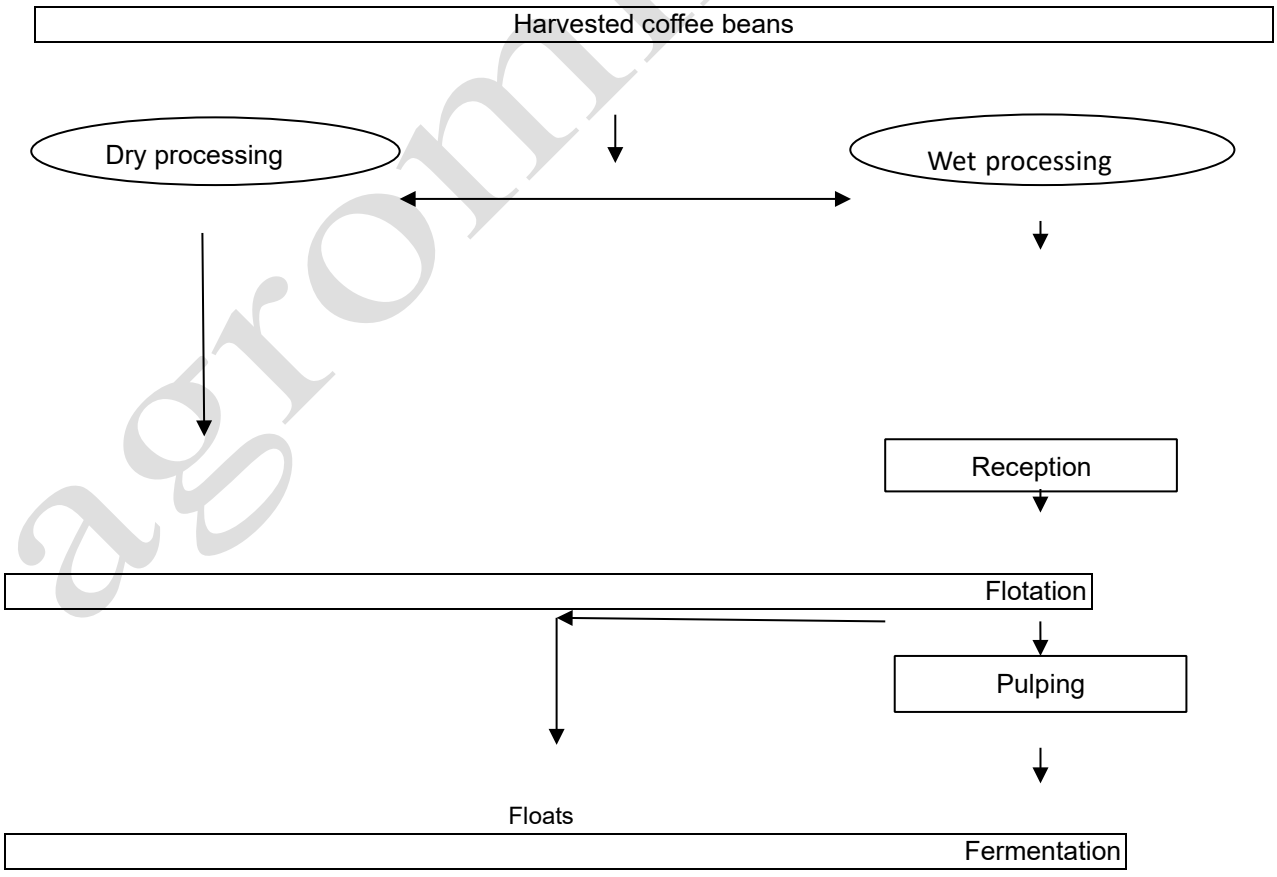
Artificial- below 60° C (Driers – Static, rotary, horizontal, vertical models)

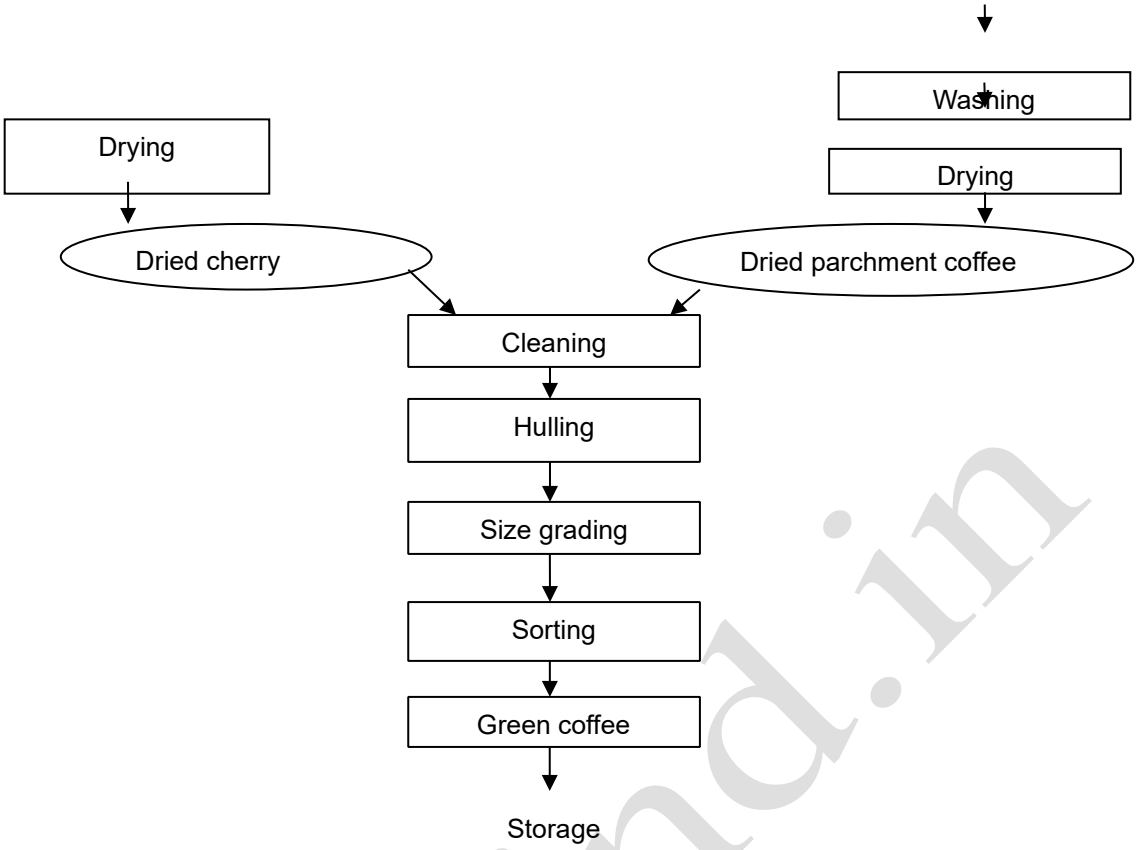
Wet processing:

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

Processing:

Various stages of dry and wet processing





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

Major Coffee Producing Countries

• South America:- brazil, Columbia, Venezuela

• Africa:- Kenya, Ethiopia etc.

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

• Asia:- India, Indonesia.

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

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

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

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

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

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

Arabica – 105500, Robusta - 239250, Total - 344750

Uses of Coffee:

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

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

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

Species and cultivars (50-60 in the genus)

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

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Backing showers	Apr-May	Mar-Apr
Shade	Medium-light	Light shade
Fruit maturity	8-9 months	10-11 months
Yield	2500-3000kg/ha	1250-1750kg/ha
Pollination	Self	Cross

Varieties

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

Robusta varieties

Sln 274, Sln 270, Sln 3

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

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

Soil and climate

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

Seeds and sowing: Coffee is propagated by seeds

Season: June - December

Preparation of seeds

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

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

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

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

Nursery practices

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

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

Sowing

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

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

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

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

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

Bag nursery

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

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

Seedlings are planted in polythene bags

Preparation of field

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

Terracing should be done in deep sloppy areas.

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

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

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

Planting is done along the contour in slopy areas.

Spacing

Arabica Coffee: 1.5 to 2.0 m either way.

Dwarf varieties: Sanraman: 1 x 1 m.

Robusta coffee: 2.5 m either way.

Planting shade trees

Dadap is commonly used as a lower canopy shade.

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

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

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

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

Silver oak trees are planted for permanent shade

Irrigation

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

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

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

Aftercultivation

Weeding and mulching should be done as and when necessary.

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

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

Prune water shoots and disease affected shoots.

Harvest

Harvest starts during November and harvesting extends up to February.

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

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

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

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

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

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

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

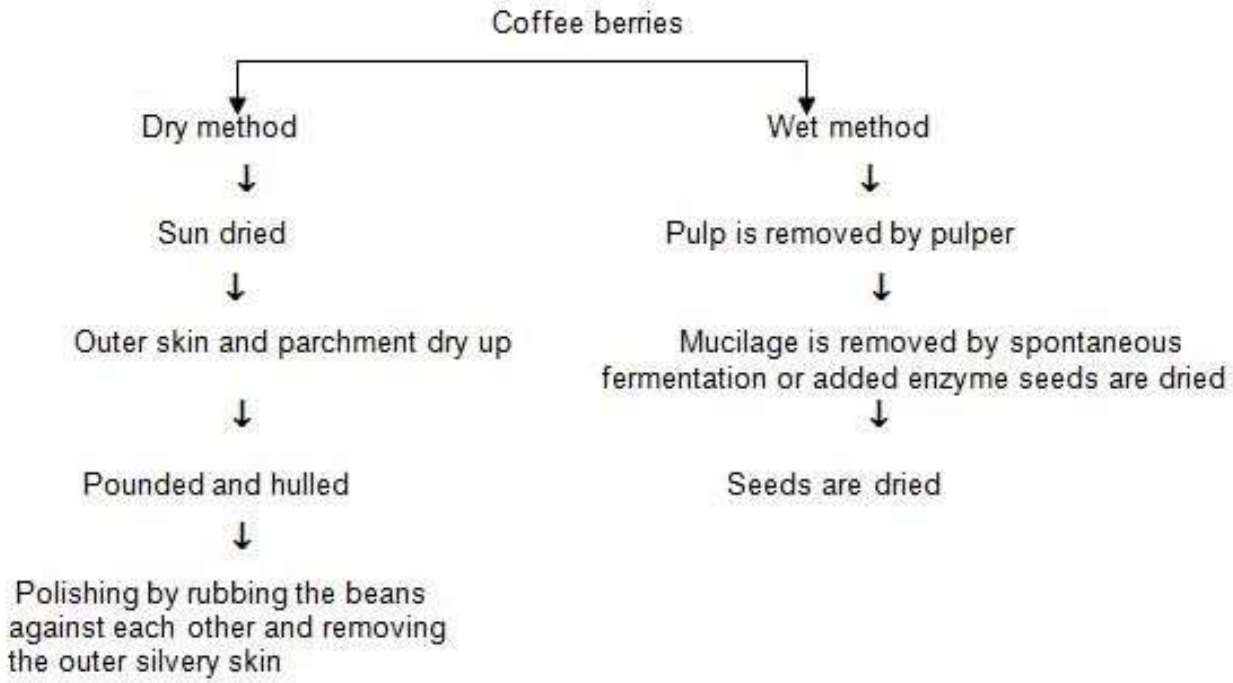
- **Yield**

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

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

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

Coffee curing process



Pulper cum Washer for Coffee

Function : To pulp and wash the coffee parchments

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

Cost of the unit : Rs. 75,000

Cost of operation : Rs. 25/h

6. Salient features

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

Preparation of Parchment Coffee/Washed Coffee:

1) Pulping:

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

2) Demucilaging and Washing:

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

a) Natural Fermentation:

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

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

The process of fermentation

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

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

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

b) Treatment with Alkali

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

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

c) Removal of Mucilage by Friction.

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

2. Under Water Soaking:

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

3) Drying:

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

The dried beans are stored in gunny bags.

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

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

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

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

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

TEA

Camellia sinensis

Family: Camelliaceae

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

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

Introduction

Origin – China / South East Asia,

Distribution: India, China, Sri Lanka and Indonesia.

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

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

Indian Tea Industry

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

Botany

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

Comparison between Assam and China Jats

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

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

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

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

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

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

4 weeks – sprouting of axillary bud

5-6 weeks – unfolding of scale leaf

6-7 weeks – unfolding of fish leaf

8-13 weeks – formation of pluckable shoot

Varieties

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

Soil and climate

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

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

Propagation

Tea is propagated by cuttings.

Nursery

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

Pre-treatment of rooting medium

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

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

Preparation of sleeves

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

Selection of mother bush and its treatment

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

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

Preparation of cuttings

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

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

Grafting

Even cleft grafting of single nodal cuttings is followed

Manuring of nursery

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

Hardening of the cuttings

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

Single Hedge System

In this method, the spacing adopted is 1.20 x 0.75 m accommodating 10,800 plants/ha.

Double Hedge System

In this method, the spacing adopted is 1.35 x 0.75 x 0.75 m accommodating 13,200 plants/ha.

Season and planting - May - June or September - October

Irrigation

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

Manuring

Manuring should be done 2 months after planting. Phosphorous should be applied at 80 - 100 kg/ha as Rock phosphate once in a year by placement at 15 - 25 cm depth up to the first pruning and thereafter once in two years. N : K ratio 2 : 3 should be adapted for the first 3 years and a ratio 1 : 1 thereafter.

Year of application	Total weight kg/ha/annum		No. of applications
	N	K	
I year	180	270	5
II year	240	360	6
III year	300	450	6

IV year onwards	300	300	6

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

After cultivation

Mulching

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

Weed control

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

Liming

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

Shade and its management

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

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

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

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

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

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

Pollarding

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

Training young tea

Cantering

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

Tipping

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

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

Pruning

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

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

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

The different types of pruning are as follows

Type of pruning	Pruning height (cm)	Season	Remarks

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

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

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

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

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

Plucking

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

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

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

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

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

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

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

Plant protection

Scales

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

Thrips and Aphids

Thrips and Aphids can be controlled by spraying Phosalone 35 EC

Mites

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

Diseases

Blister blight

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

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

Yield

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

Manufacturing of tea Types

of processing

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

Steps

1. Withering

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

2. Rolling

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

3. Fermentation

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

4. Drying

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

5. Grading

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

Orthodox grades	Mesh size	CTC Grades	Mesh size

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

Green tea

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

Non-withered tea

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

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

Pickled tea

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

Instant tea

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

Caffeine free tea

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

Oolong tea

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

Silver tips tea

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

Handmade tea

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

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

TEA

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

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

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

Possess remarkable disease fighting properties.

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

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

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

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

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

Tea is grown in 16 states in India.

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

Tea Growing Areas in south India

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

Nelliampathy (Palghat, Kerala)

High Range (Idukki District, Kerala)

Vandiperiyar and Peermade (Idukki District, Kerala)

High Wavys (Madurai District, Tamil Nadu)

Trivandrum (Kerala)

Singampatty (Tirunelveli, Tamil Nadu)

Coorg (Karnataka)

Hassan (Karnataka)

Chikmagalur (Karnataka)

TEA cultivars with special characters

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

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

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

Soil and climate

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

5.5.

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

Optimum temperature: 20 - 27^0 C

Nursery

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

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

Pre-treatment of rooting medium

Treating with Aluminium sulphate can reduce soil pH.

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

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

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

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

- **Preparation of sleeves**

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

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

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

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

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

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

Total	**80 parts by Wt**

- **Hardening of the cuttings**

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

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

- **Methods of planting Single Hedge System**

  In this method, the spacing adopted is 1.20 x 0.75 m accommodating 10,800 plants/ha.

- **Double Hedge System**

  In this method, the spacing adopted is 1.35 x 0.75 x 0.75 m accommodating 13,200 plants/ha.

Season and planting

May - June or September - October

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

Manuring

Manuring should be done 2 months after planting.

Phosphorous should be applied at 80 - 100 kg/ha as Rock phosphate once in a year and thereafter once in two years.

N: K ratio 2: 3 should be adapted for the first 3 years and a ratio 1: 1 thereafter.

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

			6	23	15
			6	29	18
			6	33	19

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

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

Aftercultivation

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

Training young tea

Centering

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

Tipping

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

Pruning

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

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

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

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

Rejuvenation pruning

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

Hard pruning

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

Medium pruning

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

Light pruning

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

Skiffing

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

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

Annual lopping

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

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

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

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

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

Yield

The yield of green leaves is 10 t/ha

Tea Board

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

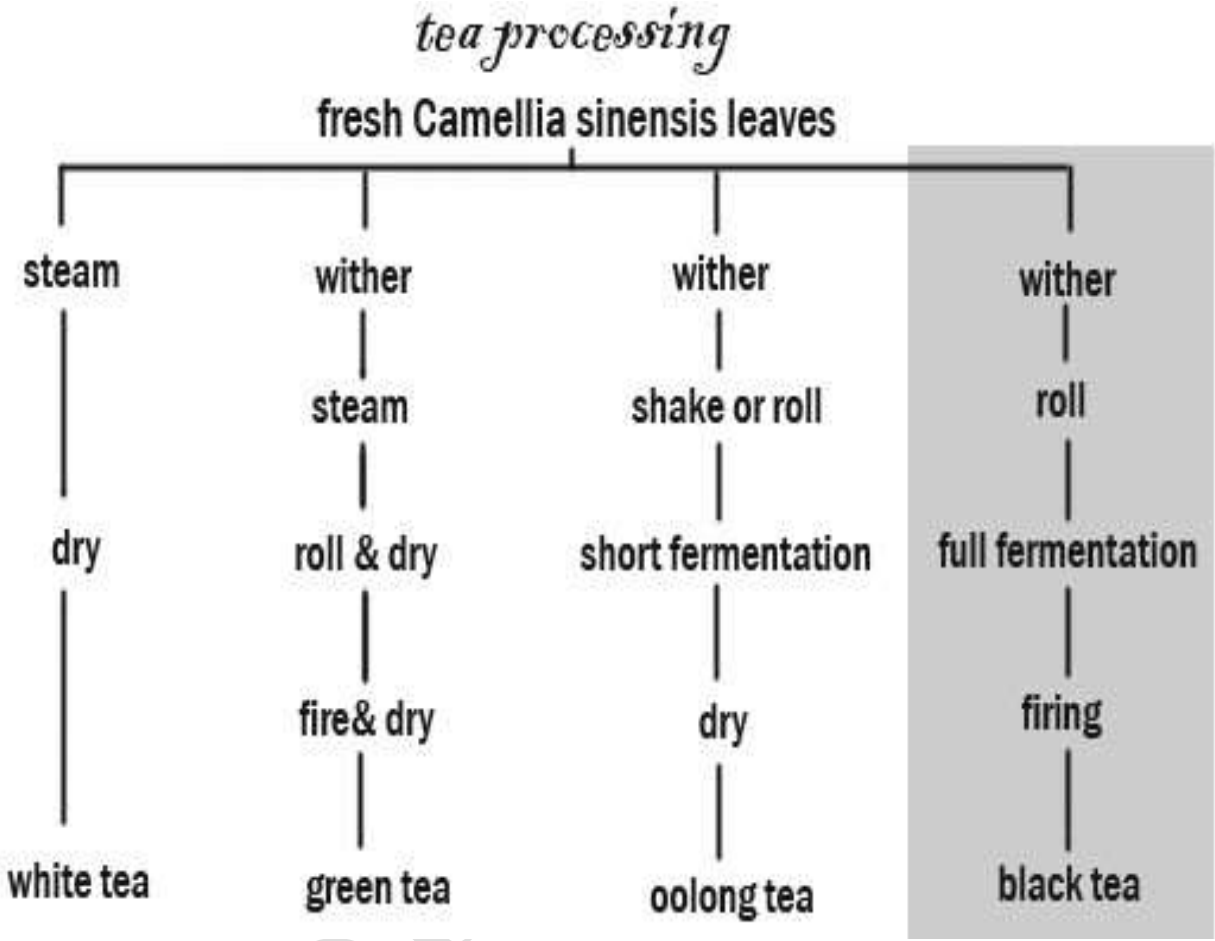
TANTEA- Tamilnadu Tea Plantation Corporation Limited (an undertaking of the State Government of Tamilnadu, India)

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

Tea processing

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

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



Two types of processing.,

Orthodox method

CTC method

Orthodox method

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

CTC method (cutting, tearing & curling):

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

Tea leaf processing methods

Plucking

Withering/ Wilting

Disruption

Oxidation / Fermentation

Fixation / Kill-green

Sweltering / Yellowing

Rolling / Shaping

Drying

Aging / Curing

Plucking

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

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

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

Withering/ Wilting

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

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

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

Disruption

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

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

Oxidation / Fermentation

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

Fixation / Kill-green

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

Sweltering / Yellowing

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

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

Rolling / Shaping

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

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

Drying

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

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

Aging / Curing

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

Grading

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

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

Orthodox grades:

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

CTC grades

Flowery pekoe (FP)

Pekoe

BOP

Pekoe fanning

BOP-fanning

Pekoe Dust (PD)

Red Dust(RD)

Super Red Dust (SRD)

Fine Dust(FD)

Rubber (*Hevea brasiliensis)*

Euphorbiaceae

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

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

Origin:

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

Major areas: Indonesia (25 lakh ha)

Major producer: Thailand (25 lakh MT)

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

Major consumers: USA, China, Japan, India.

Composition:

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

Uses:

Auto tyres and tubes- 45%

Cycle tyres and tubes- 13%

Camel black, belts, hoses- 12%

Foot wares- 11%

Latex foams- 5%

Others:

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

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

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

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

Hevea:

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

Cultivars: Rubber Research Institute of India

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

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

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

Propagation:

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

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

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

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

Spacing: 5mX6m

Population Buddings – 170 to 180 plants/ac

Seedlings- 180 to 210 plants/ ac

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

Cover crops: to prevent soil erosion.

Calapagonium mucunoides, Mucuna bracteates **Shade :**

Albizzia & Gliricidia are used.

Fertiliser:

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

Pest and Disease:

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

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

Powdery mildew: Wettable sulfur.

Pests: Scales, Mealy bug, termites.

Harvest:

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

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

Tapping height:

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

Seedlings at 50cm girth 90cm height from ground.

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

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

- V- cut system
- Herring bone system

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

Tapping intensity:

Quarter cut tapped daily is 100 %(standard)

South India, 1. Half spiral system S/2

2. Alternate day tapping d/2

3. 100% are employed.

Tapping knife: "Miche Golledge"

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

Tapping cups:

i. Earthen ware- mostly used, cheap & heavy

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

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

Slaughter tapping:

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

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

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

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

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

0.02%.

LECTURE 20

CASHEW

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

Cashew in India

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

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

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

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

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

Origin and Distribution of cashew

Origin:

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

Distribution of cashew

World:

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

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

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

Table: Major cashew producing countries in the world

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

Distribution in India

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

Area, Production & Productivity of Cashew nut in India

A - Area in '000 Ha.

P - Production in '000 MT.

APY - Average Productivity in Kg per hectare

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

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

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

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

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

Export earnings from India (2007-08)

More than 2500 crore INR

CNSL rate (2008) = Rs 26/kg

Soil and Climatic Requirements

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

Avoid soils which are

Heavy, Water logged and Excessive alkaline and saline soils (ZË¼ÀÄ) as tap root will bend when reaching heavy soil.

Roots of cashew:

Cashew has

1) Tap root --- Penetrates deep into soil,

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

Rhizosphere of cashew :

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

Surface spread : upto 2 m radius from the base.

Climate for cashew:

It is a sun loving tree and does not tolerate excessive shade. It cannot tolerate temperature above 45^0C during fruit set and development stage. Cashew is a tropical crop, loving warm and humid /moist climate of tropics.

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

2) **Latitude**:

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

a) Every 400 feet altitude

b) Every 1º Latitude and

c) Every 5 º Longitude (From West to East) there will be delay in flowering by four days.

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

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

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

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

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

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

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

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

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

Question Bank

1.Cashew belongs to the family ---------- (Anacardiaceae)

2.Write about the importance and scope of cashew cultivation in India

3.Cashew is originated from ---------- (Brazil)

4. Write about the climatic requirement of cashew

5. Write about the distribution of cashew in India

LECTURE 21

CASHEW VARIETIES

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

25 varieties are from selection in the germplasm and

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

Cashew Varieties - for Karnataka

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

Varieties recommended for Karnataka includes;

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

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

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

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

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

10) VENGURLA - 4

Mean nut yield / tree: 17.2 Kg

Nut weight : 7.7g

Shelling % : 31

Export grade : W210

11) VENGURLA - 7

Mean nut yield / tree: 18.5 Kg

Nut weight : 10g

Shelling % : 30.5

Export grade : W180

Varieties of Maharashtra

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

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

V-4 is popular in Belgaum District.

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

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

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

Hybrids: V-3 to V-8 are hybrids

Varieties of Andhra Pradesh

Bapatla 1 to Bapatla -6 (BPP-6)

Varieties of Tamil Nadu

Vridachalam (VRI) – to VRI-4

Varieties of Kerala

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

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

Priyanka and Anagha are from Annakayam research station.

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

Propagation in cashew

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

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

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

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

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

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

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

Planting and management of grafts in the main field

The softwood grafts are planted in pits of 50 cm^3 with topsoil and 5-10 kg of compost or dried cow dung per pit after removing the polythene bags during June- July. Care should be taken while planting to see that the graft union is 2.5cm above the ground level. The polythene tape is to be carefully cut and removed. Staking should be done immediately after planting to protect the grafts from damage.

Top working in cashew,

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

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

2. Beheading of trees:

a. **Time and season of beheading :** December to February

b. **Remove branches :**

c. **Stumping: Cutting** stump at 0.50 m to 0.75 mabove ground level with saw to avoid bark splitting.

d. Smearing cut portion : Smear the cut portion with BM – 10 % paste or cow dung slurry and red soil.

e. **Basin rectification :** Prepare a basin of 1.50 m radius

f. **Plant protection :** Paste sevin dust + Blitox (50 g sevin dust + 50 g blitox per liter of water)

g. **Provide shade.**

3. Sprouting of beheaded trees:

a) Sprouting: New sprouts appear in 30 to 40 days after beheading.

b) Remove shade

c) Thinning: Retain 10 to12 healthy shoots/sprouts for grafting and remove others.

d) Periodical removal of new sprouts to facilitate the growth of selected sprouts.

4. Selection of Scions:

a. Select scions from high yielding varieties

b. Pencil thick and 12 to 15 cm long scion stick with a sprouted bud should be selected from shoots of 3 to 4 months growth.

c. Preconditioning: Remove all the leaves 7 to 8 days before grafting.

d. Fresh scion is always preferred for better success.

5. Grafting:

a. Select 10 to 12 sprouts for grafting.

b. Cut the sprout 5 to 6 cm from the top and split it in the middle to 3 – 4 cm depth with the help of a knife.

c. Technique of grafting : Wedge grafting

d. Select the scion of the same thickness and give a cut to form a wedge or "V" shape.

e. Insert the scion: Firmly tie with the help of polythene strip.

f. Cover the grafted portion with the help of polythene bags./ caps

6. After care:

a) Sprouting in 10 to 15 days. About 5 to 6 successful grafts are sufficient per tree.

b) Remove excess and unsuccessful shoots.

Advantages of top working

I. Vigorous growth: Top worked trees are vigorous in growth, because of well established root system.

II. Top worked trees starts yielding from second year itself after rejuvenation.

III. Higher average yield and high yield during their life time.

2 nd year = 4kg

3 rd year = 6 kg

4 th year = 8 kg per tree when compared to 2 kg per tree in old plantation (Before top working / rejuvenation) which is 3-4 times more than that of earlier yields of 2 kg per tree.

IV. Cost involved for top working could be recovered from the sale of wood in the first year itself.

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

VI. We can have different varieties of cashew on a single tree

Question Bank

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

LECTURE 22

ESTABLISHMENT AND MANAGEMENT OF PLANTATION

Establishment and management of plantation

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

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

Planting time: With the onset of monsoon.

Planting :

Pit size : 60 cm x 60 cm x 60 cm

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

Spacing in cashew may be adjusted based on

1) System of planting

2) Moisture status of soil

3) Fertility status of soil

4) Variety and

5) Planting material used etc.

High Density Planting in Cashew

Experiments were carried out at NRCC Puttur and in AICRP on cashew centers in different parts of the country with plant population ranging from 156 to 2500 trees per ha in order to study the effect of high density planting in cashew towards enhancing productivity
Present recommendation of plant density in cashew varies from 156 plants (8 mx8m) to 200 plants per ha.
Spacing for High density plantations (Depending upon agroclimatic conditions)

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

4 m x 4 m or
8 m x 4 m or
7 m x 4 m or

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

5 m x 5 m or
6 m x 6 m or with a population varying from 312 to 624 plants per ha
Poor soils are more suitable for HDP due poor canopy expansion.
Age /period of thinning of plants: After 7 to 10 years depending on the spread of canopy.

Spacing maintenance after thinning
Set – I = 8 m x 8m
Set – II 8 m x 8m or 10 mx 10 m or 6m x 8 m

Advantages of HDP:

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

Varieties suited: Dwarf varieties with compact branches are well suited.
Eg. Anakkayam -1 and Dhana.

Manuring

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

FYM: Application of 10-15 kg of farm yard manure or compost per plant is beneficial
Biomass available in cashew for recycling : 5 to 6 tonnes per ha about 15 to 20 kg leafy biomass per tree is available in cashew

Inputs per ha

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

Year	May - June			Sept - October		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
I	50	40	--	50	40	--
II	100	40	30	100	40	30
III	200	60	60	200	60	60
IV	250	60	60	250	60	60

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

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

Method of application:

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

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

Method of fertiliser application

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

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

Irrigation in cashew:

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

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

Experiments at DCR Puttur has shown that,

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

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

PRUNING OF ADULT CASHEW TREES

Limb pruning is suggested in cashew (At Puttur conditions)

Height of beheading: 1 m of stem

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

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

Kolar conditions = August – Sept’

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

Limb pruning increases cashew yield by flushing

Question Bank

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

LECTURE 23

PLANT PROTECTION IN CASHEW

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

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

Diseases in cashew

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

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

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

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

Rainy season: Minimum activity and lives on alternate hosts

Management of TMB

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

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

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

3) Bio control including botanicals: Botanicals including Pongamia oil, neem oil etc were found to be non effective

4) Chemical control: Four sprays at an interval of 2 to 3 weeks from middle October coinciding with new flush.

New flush = October – November

New inflorescence = Dec to January

1) Cashew stem and root borer (*Ploceaederus ferrugineus L.*)

A dreaded enemy of cashew leading to death of the tree this pest is more severe in neglected cashew plantation.

Methods of damage = Grubs comes out and bores into the bark and feed on the epidermal and vascular tissues = Tunneling of stem and roots

Symptoms

1) Presence of small holes in the collar region
2) Gummosis : Oozing of gum
3) Frass extrusion : Extrusion of chewed up fibres and excreta
4) Bark discolouration
5) Foliar Yellowing : Yellowing and shedding leaves
6) Dreaded enemy : Death of tree

Management of CSRB:

1) Identification in the initial stage of infestation: Do not treat trees which are in the stage of showing yellowing even in the monsoon. Yellowing is the stage before the death of cashew.
2) Phytosanitation: By the removal of dead trees and trees which are showing particularly at the end of monsoon.
   a) **Yellowing**: complete yellowing due to CSRB infestation
   b) **Boring**: Showing more than 50 per cent damage to the bole :
3) Mechanical removal of the immature stages of the pest : The grub has six instars and remove the pest in the initial stage of development to avoid damage of tree. While removing the grub damage the bark to the minimum extent.
4) **Treatment/ Swabbing : Swabbinng or P**asting the damaged portion with mixture of Carbaryl 50 gm (50%) and copper Oxychloride (25 gm) in one liter of water give effective control. We can also use Chloropyriphos or lindane pasting

Preventive treatment: Swabbing with Coal tar + Kerosene (1: 2) to a height of 1 m trunk four times in year.

Harvesting, yield, processing and grading in cashew

Pre flowering age in cashew: 3 to 4 years

Full bearing age = 10 to 12 years

Economic life = over 50 years (35 to 40 years and even upto 60 years).

Stage of harvesting: Fully mature nuts, Cashewnuts when fully mature look greyish brown.

Method of harvesting

a) Collection of fallen nuts: It is better to pick the fallen nuts because there is a possibility of harvesting immature nuts which leads to poor quality kernel during processing.
b) Periodical plucking of apple : For preparation of cashew apple products one has to pluck the fruits from the tree. If it is fully mature the fruit just drops.

Yield in cashew: 10 to 15 kg per raw nuts tree (Apple yield is 8 to 10 times than that of seed yield)

Processing in cashew nut: Harvested nuts will be dried for 2 to 3 days

Nuts after drying can be stored in gunny bags well protected from rodents and stacked on a platform above the ground level leaving space on all the sides of the room.

Well dried raw nuts (moisture content 8 to 9%) could be **stored upto one year** without any quality deterioration

Processing in cashew refers to the recovery of kernel from mature nuts by manual or mechanical means.

Mechanical processing involves

Moisture conditioning (Moisture content in the nut is increased to 15 to 25 %) === Roasting ==== Shelling ==== Peeling (Removal of seed coat or testa) -drying === Grading ==== Packing (Vacuum packing extends shelf life in cashew by additional one year) = Marketing

Roasting: Makes shell brittle

Methods of roasting

1) Drum roasting: Results in high percentage of wholes . Dis advantage here is loss of CNSL.
2) Oil bath roasting: Shell gets heated and shell wall gets separated releasing oil into bath. i.e. CNSL is recovered.
3) Steam boiling

   Shell contains 35 % CNSL and CNSL contains anacardiac acid to an extent of 90 %.

CASHEW NUT SHELL LIQUID - A versatile Industrial Raw Material

1. This raw material is used for a number of polymer based industries like paints and varnishes, resins, industrial and decorative laminates break lining and rubber compounding resins. (For more details contact Regional Research Laboratory, Trivandrum, Kerala.
2. The nut has a shell of about 1/8 inch thickness inside which is a soft honeycomb structure containing a dark reddish brown viscous liquid. It is known as cashew nut shell liquid, which is present in the pericarp of the cashewnut.
3. In India annual production of CNSL will be around 15,000 tonnes where as the potentiality available is around 45,000 tonnes and the world production of CNSL will be around 1.25 lakh tones.

GRADING IN CASHEW

Basis of grading: Based on counts i.e., number of kernels per pound i.e., 453.5 g

CEPC (Cashew Export Promotion confirms grade specification and recognizes 24 different grades of kernels

I	Main grades	Wholes – Good, big sized kernel (Export quality) Eg. W-180
2	Second grades	Whole – good, medium sized kernels (Export quality)
3	Third grades	Halved and broken (Sold locally)
4	Fourth grade	Rejected and spoiled (Sold locally)

Grades of Whole kernels in cashew (Wholes are the kernels which have no split). These are again separated in to 6 grades as

I	Grade	Whole Kernels per lb	
2	W-180		Best grade in the world cashew market
3	W-210	200-210	
4	W-240	220-240	
5	W-280	260 – 280	
6	W-320	300-320	Rates in the world market are based on this grade
7	W-400	350-400	
8	W-430	400-430	

Question Bank

1. List out the major pests of cashew
2. Suggest management practices for tea mosquito bug
3. ---------- pest kills cashew tree (Cashew stem and root borer)
4. Cashew is harvested at ---------- stage of maturity (Fully mature nuts)
5. CNSL stand for (Cashewnut Shell Liquid)
6. Write about grading of cashew kernel

COCOA (*Theobroma cacao* L.)

Introduction

Family : Sterculieaceae,

Cocoa is a popular beverage crop after tea and coffee

Theobroma : Name given by Linnaeus meaning " Food of the Gods

Greek name Theos = Gods and Broma = Food

Cocoa consumption is mainly in temperate countries.

Europe : 50 percent of consumption of cocoa produced in the world

America : 40 percent of consumption of cocoa produced in the world

Cocoa is relatively a new crop in India,

Cocoa (**Theobroma cacao L.**) is a native of Amazon region of South America. The bulk of it is produced in the tropical areas of the African continent. There are over 20 species in the genus but the cocoa tree Theobroma cacao is the only one cultivated widely.

Cocoa being a tropical crop, India offers considerable scope for the development. Cocoa is mainly grown in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu.

Importance:

Though cocoa has been known as the beverage crop even before tea or coffee, it is relatively a new crop in India. Cocoa being primarily an item of confectionery industries is the produce of Cacao plant mostly grown as a companion crop interspersed within the irrigated Coconut and /or Arecanut gardens. Even though Cocoa comes under the definition of plantation crops pure plantation of cocoa as such is absent in India. The commercial cultivation of cocoa however commenced from 1960's only. Various Cocoa products are confectionery in nature and consumable with palatable ness. Internationally it is an item largely consumed in developed countries. India has gained a foreign exchange of nearly Rs. 9.00 crores in 1995-96 and Rs. 6.00 crores in 1996-97 by way of export of cocoa beans and its products from India. At present the global production and consumption of cocoa is around 27.00 lakh MT, compared to this, India's production is meager i.e. 10,000 MT.

Early sixties : Introduced to India for commercial cultivation

> 1965 : Commercial cultivation of cocoa

1970's : Large scale cultivation of cocoa

Origin and distribution,

Origin : Cocoa is native of Amazon region of South America.

- ❖ Under storey crop of rain forest in its natural habitat. Since 2000 years: Cocoa was under cultivation in Central America. Central American cocoa is Criollo cocoa.

Distribution :

World : About 35 countries in the world are producing and exporting cocoa

Ghana, : African country : 30 per cent of world production.

Nigeria, : African country.

Ivory Coast, : (In Western Africa by the western side of Ghana) Leads in the world with 40 per cent of world production followed by Ghana (30 %)

Brazil : 20 per cent of world production

Cameroon and Malaysia.

Asia : Only 2 % of world cocoa production Central American cocoa : Criollo

Are and production of cocoa in the world

	Area Harvested (Ha)	Yield (Hg/Ha)	Production (tonnes)
Côte d'Ivoire	2000000	6108	1221600
Indonesia	1000000	8000	800000
Ghana	1656000	4000	662400
Nigeria	1370000	2700	370000
Cameroon	600000	3766	226000
Brazil	635975	3435	218487
Ecuador	398104	3028	120582
Togo	138160	7599	105000
Papua New Guinea	128000	3984	51000
Dominican Republic	173000	2901	50200
Colombia	127988	3855	49348
Peru	68860	5246	36124

Mexico	61317	3695	22661
Venezuela (Bolivarian Republic of)	50000	4000	20000
Malaysia	20561	8828	18152
Uganda	43000	3488	15000
India	34049	3471	11820
Total	8733093	249772	4082270

Earlier cocoa was grown mainly in South America (Brazil, Ecuador and neighboring countries). Now two thirds of the world production is from Africa (Ghana and Nigeria)

India:

Early 1970's : Commercial cultivation in India started.

80 % of cocoa plantations : As intercrop/mixed crop with arecanut and coconut plantation

20 % of cocoa plantations: Under crop of partially cleared forest.

Area : 11,000 ha

Production : 7,000 tonnes

Productivity : 605 kg per ha

Marketing of cocoa in India is controlled by few companies like Cadbury's, Sathe etc and they import cocoa at lower rates. Now cocoa crop is included under CAMPCO (Central Arecanut and Cocoa Marketing and Processing Co- Operated Limited)

State wise Area, Production & Productivity of Cocoa

A - Area in Ha.

PDN - Production in MT.

PDY - Productivity in Kg./Ha.

STATE	**2008-09**			**2009-10**		
	A	**PDN**	**PDY**	**A**	**PDN**	**PDY**
Kerala	10708	6100	685	11044	6344	592
Tamil Nadu	8500	230	350	9347	900	443
Karnataka	7250	2890	600	8958	7250	3006

A.Pradesh	14061	2600	565	16969	2704	192
TOTAL	40519	11820	550	46318	12954	380

http://dccd.gov.in/stat2.htm#State

Sl No.	**State**	**Area (% of total area)**	**Production (% of total production)**
1	Kerala	79	71
2	Karnataka	18	25
3	Other states viz., AP, TN. Etc		

There is scope for expanding area in TN, Goa, Maharastra and North Eastern region, Andaman and Nicobar islands

Climate and soil

Climate and Microclimatic requirement: Cocoa is a tropical crop. In its natural habitat cocoa is a small tree in the lower storey\under storey of the evergreen tropical forest of South America. The tree can not withstand high winds drought and sudden fall in temperature. The microclimatic environment around the cocoa plants consists of a high humidity at all times. It prefers high temperature under partially shaded situation.

Latitude : 20º N and 20 º S but maximum concentration is between 10º N and 10 º S

Temperature: Temperature range of 15 to 39º C with a an optimum temperature of 25 º is considered ideal. Temperature below 10 º C and annuall average temperature is less than 21 ºC. Cocoa responds well to high temperature (30 ºC to 32 ºC) than lower temperature.

Rainfall : In the absence of irrigation facilities minimum requirement of rainfall is about 150-200 cm per year. Ideally cocoa requires a minimum of 90-100mm rainfall per month with an annual precipitation of 150 -200 cm. Rainfall can be supplemented with irrigation during dry periods.

Altitude : Preferably below 300 M asl. However, it can be grown up to 900m.

Relative Humidity : It prefers hot and humid atmosphere (> 80 % through out the year) is essential for optimum development of cocoa trees. Humidity has to be maintained near saturation

Microclimatic requirement :

Cocoa needs sunlight to be screened to a certain extent particularly during dry weather period. Cocoa is a under storey crop of Amaon fores of S.America.

It can be profitably cultivated where 50 % of light is available. In India, coconut and arecanut plantations are best suited for cocoa cultivation.

Under arecanut 30-50 percent of sunlight penetrates through the canopy, which can be intercepted by cocoa.

Shade can not limit cocoa production when all other environment factors are favorable viz.,

- Optimum temperature : 30-32 º C
- Excellent average RH :
- Optimum rainfall
- Humus rich soil enriched with fertilizer etc.

Soil : Deeper and richer soils are favorable. The best soils are forest soils rich in humus. A minimum of 3.5 per cent Organic matter in top 15 cm soil is expected for ideal growth**.**

Deep : (i.e., > 1.5 m)

Well drained :

P^H: 6.5 to 7.0 is ideal. However, it thrives on wide range of soil types with PH ranging from 4.5 to 8.0

Note: At lower pH (<5.0) : Less availability of P and toxic quantity of Fe, Mn, Cu and Zn. And at higher (> 7.0 P^H) Deficiency of trace elements particularly Zn.

Varieties : Varieties / cultivars

There are three main types of cocoa viz.,

1) Criollo group : Here pods are red before ripening, varying in shape and turn yellow on ripening. Its fruits have furrows on fruit surface and have rough warty fruit surface.. It is generally poor yielder with slow growing habit and small leaves. It is susceptible to various diseases.

Criollo types have very weaker chocolate flavour but may have other flavours and is highly priced by some buyers.

2) Forestero group : It is the commercially cultivated type of cocoa in major cocoa growing countries. Here pods are green before ripening and turn yellow on ripening. Pods are of smooth surface and have shallow furrows on it. Seeds have dark purple cotyledons and seeds are more or less flat.

When compared to Criollo it is more vigorous and high yielder. It has good plane chocolate flavour and good for milk chocolates

3) Trinitarios Group of cocoa : It is originally selected from Trinidad. It is heterozenous type probably resulting from Foretero and Criollo cross. It has botanical features of intermediate nature between Criollo and Forestero types. The product of this group is also of intermediate in quality.

The cocoa cultivars in different countries vary with the region from which they were introduced and the amount of hybridization. Commercial cocoa has two major varieties, Criollo and Forestero which differ in many aspects as follows.;

Sl. No	**Features**	**Criollo**	**Forestero**
1.	Cotyledons	Plumpy & white when fresh & on fermentation attains cinnamon colour.	Flat and purple when beans are fresh and turn dark chocolate brown on fermentation. turn dark chocolate brown on fermentation
2	Plant vigour	Less	More vigourous than Criollo
3	Colour of the pod	Dark red	Green when immature and turn yellow on ripening. and turn yellow on ripening.
4	Other pod characters	Rough surface, ridges prominent, pronounced point and thin walled.	Smooth, inconspicuous ridges, thick walled, melon shaped with rounded end
5	Beans per pod	20-30	> 30
5	Flavour and aroma and quality	Mild flavour and pleasant aroma with superior quality and are priced more than that of Forestero types.	Harsh flavour with bitter taste
6	Duration of fermentation	3 days	6 days

7	Adoptability in India and yield level	Poor adoptability and low yield and hence discouraged for commercial cultivation	Adoptable with higher yield level and hence recommended for commercial cultivation not only in India but also in the entire world.
8	Disease reaction	More susceptible for disease particularly that are caused by *Phytophthora palmivora*	Less susceptible

Other types of cocoa includes

1) Trinitario: A hybrid between Criollo and Forestero from Trinidad.
2) Amelonado: A Forestero type bean with a melon shaped pod cultivated in west Africa.
3 Amazon: Vigourous growing and high yielding type collected from Amazon forests.

The accession numbers of I-21, II-11, II-18, II-67, III-5, III-101 from Malaysian collection were having desirable characters like high yield, bean weight of more than one gram and are recommended for cultivation in South India.

Propagation in cocoa :

Cocoa can be planted either as

1) Seedling or through
2) Vegetative propagated material

Seed propagation: At present, commercial propagation of cocoa is through seedlings.

Use ripe pods and seeds will lose viability soon after they are taken out of pods. Hence, fresh beans are used for sowing. Seed viability can however be enhanced for several weeks when kept mixed with charcoal. Pods as such stored in polythene bags and dry charcoal powder retained viability upto a period of 30 days.

Vegetative Propagation

Cocoa being a cross pollinated plant seedlings show considerable variability. Vegetative propagation is through

1)cuttings,

2)budding : i.e., Forket method of budding or 3)soft wood grafting.

3) Grafting (Soft wood grafting) :The soft wood grafting technique was first standardized at Vittal Station of CPCRI using four months old seedlings as root stock. Scion collected from high yielding plants with other desired characters, were grafted on the seedlings which gave 60-80% success

Soft wood grafting in cocoa : Vegetative propagation is important since true to type trees are produced. Soft wood grafting is a more preferred vegetative method for production of planting material. The material consists of cleft grafting of scions to 2-3 month old seedlings root stocks.

http://dccd.gov.in/ctech.htm#about

Age of root stock : 2- 3 months old

Length of scion stick : 12-14 cm

The scion sticks should be 12-14 cm long and secured to root stock cleft by 1.5 cm wide polythene tape. Graft union takes place within one month . The grafts will be ready after 3 months for planting.

Planting cocoa as mixed crop with arecanut/Coconut plantation.

Pit size : 50 cm x 50cm x 50 cm

Fill pits with top soil and 25 kg FYM an plant seedlings of 6 months old

A) Under Forest areas (As pure crop) : Forest trees are thinned to the desirable shade levels if natural partial shade is available. Other wise plants of silver oak or glyciridia may have to be raised 2-3 years before planting of cocoa.

Spacing : 2.5 m x 2.5 m to 3.0 m x 3.0 m

Cocoa can be successfully cultivated as a mixed crop with both arecanut and coconut. In India cocoa cultivation is under coconut and arecanut gardens.

B) Cocoa as a mixed crop with arecanut :

Both arecanut and cocoa needs shade during the first two hot weather seasons after planting. Banana can be grown as a shade crop. During subsequent years shade cast by areca palms will provide the required shade for cocoa.

Spacing and alignment

Spacing for arecanut (Main crop	:	2.7 m x 2.7 m
Spacing for cocoa	:	2.7 m x 5.4 m * (* = one row of cocoa for every two rows of areca)
Plant population of cocoa per ha	: 686 plants per ha.	
Drainage channels	:There will a drainage channel for every two rows of arecanut (i.e., at 5.4 m apart)	

If arecanut is planted in quincunx method at 4m x 4m spacing : Cocoa occupies the centre of the square

Spacing in arecanut plantation as a crop	Population per ha
2.7 m x 5.4 m	686

C) Cocoa as a mixed crop with Coconut:

Single hedge system :cocoa at 2.7 m apart between cocoa plants in between two rows of coconut.

Double hedge system (Paired row system) : cocoa at 2.5 m apart in double rows in between two row of coconut.

A row of cocoa is planted, between 2 rows of coconut when a spacing of 7.5 m x 7.5 m is provided for cocoa. Here cocoa is planted at a spacing of 3 m with in row (i.e., 3 m x 7.5 m) accommodating a population of 444 plants per ha. One more cocoa plant each can logically come between columns of coconut leading the population to 614 per ha (444 + 170 = 614).

If the spacing is more, it may be possible to accommodate even 3 rows of cocoa between coconut rows.

Spacing in coconut plantation as a crop	Population per ha
2.7 m x 2.7 m (single hedge)	1370
2.5 m x 2.5 m (double hedge)	1600

Manuring and irrigation,

Manuring :

FYM per tree : 25 kg at the time of planting and annually there after

Annual dose for trees of 4 years and above : :100 g N : 40 g P_2O_5: 14 g K_2O per tree per year

Dosage of fertilizer application.

Critical stages for fertilizer application in cocoa :

1. Before the main flush
2. Before flowering
3. About 2 months before the main harvest when developing crop has greater demand for nutrient.

In four equal splits during April-May, Sept-October, November-December and February-March.

Age		(Per plant per year)			
		FYM (Kg)	N (g)	P_2O_5 (g)	K_2O (g)
i	Before planting	25	--	--	--
ii	After first year	25	25	10	35
iii	After second year	25	50	20	70

iv	After third year	25	75	30	105
v	After fourth year & onwards	25	100	40	140

Apply Farm Yard Manure before the onset of monsoon. Fertilizers may be applied in four equal doses during April-May, Sept-October, November-December and February-March.

Method of fertilizer application : Ring method

Fertilizers may be applied uniformly around the base of the tree upto a radius of 75cm leaving 0.50 m at the base of the tree and forked and incorporated into the soil, to a depth of about 15cm (6").

The bands are to be widened with age. However, in mature cocoa (When canopy is properly closed) fertilizer should be broadcast on the soil surface through out the field.

Irrigation in cocoa

Cocoa plants are sensitive to drought. Young trees requires more frequent irrigation.

Summer irrigation : Cocoa requires continuous supply of moisture for optimum growth and yield. If adequate water supply is not ensured during summer yields will be reduced drastically.

Interval of irrigation in South India during summer : Weekly intervals

When as a mixed crop with arecanut : Irrigate with 175 liters of water as per the schedule given hereunder;

November – December :Once in a week

January – March : once in 6 days

April – May : Once in 4- 5 days

Drip Irrigation : Cocoa responds well to drip irrigation. @ 20 litres per tree per day

Training and pruning of cocoa

Cocoa shows dimorphic branching (i.e., Branching in morphologically distinct forms) .

Jorquette: It is the point where in chupon (i.e., vertical/orthotropic growth of seedlings) terminates to produce fan branches.

Chupon : It is the main stem coming from the seedlings i.e., vertical / orthotropic shoots. It is determinate in growth.A chupon or vertical growth of plant terminates at the jorquette where 4-5 fan branches develop. Further chupon develops just below the jorquette and continues vertical growth till another jorquette is formed.

Fan branches : It refers to the side branches which are plageotropic in growth and are almost horizontal, produced at the point of jorquette.

Pruning in Cocoa: Cocoa grows in a series of storeyes. The chupon or vertical growth of the seedlings terminate at the jorquette, where 4-5 fan branches develop. Further, chupon develops just below the jorquette and continues its vertical growth till another jorquette forms and so on.

When first jorquette develops at a height of about 1.50m (5ft) the canopy will form at a convenient height for harvesting and other operations. It is desirable to limit the height of the plant at 1.50m (I-jorquette) only by periodical removal of chupon growth. A second jorquette may be allowed to develop if the first one formed is very close to ground. Normally 3-5 fan branches are developed at each jorquette and if fan branches exceeds 5 number remove the weak fan branches.

Pruning of cocoa:

An un pruned trees produces four or more tires attaining a height of about 15 m or more. Development of branches of the new storey usually leads to degeneration of the lower storey,

Aim of pruning : To get maximum leaf area to avoid self – shading of leaves. Only the branches on the outside part of the canopy (exposed to sun light) of the tree will produce photosynthates and thus make a real contribution to the carbohydrate reserve of the tree. In a cocoa planted at 2.7 m x 5.4 m and a canopy area of 15 -20 m^2 (is optimum) is found to give higher bean yield.

Cocoa grows in a series of stories or tiers. Seedlings normally grow unbranched to a height of 1 to 2 m. The terminal bud then ceases growth and 3 to 5 lateral branches (fan branches) develop at that point of jorquette. Further increase in height is due to the development of chupon/sucker (Vertical growth) just below the jorquette.

First storey : When first jorquette developes at about 1.5 m height, the canopy will be at a convenient height for harvesting and other operations. Three to five fan branches are encouraged at each jorquette.

Plant protection in cocoa

Disease: Symptoms of attack and control measures of

I)Black pod disease ii) Charcoal rot diseases.

Diseases

(1)Black pod disease (*Phytophthora palmivora*). It also causes seedling die back in the nursery and also canker in the advance age/ stage.

Symptoms: Affected pods turn chocolate brown to black and beans become discolored.

Congenial conditions :

- ♣ Temperature below 21 ºC
- ♣ High RH
- ♣ Rainy season

Control/ Management

1) Prophylectic spray : A preventive spray with BM 1 per cent can also be given at the onset of monsoon in heavy rainfall areas.

2)Regular and frequent harvesting : Removal of infected pods at frequent intervals to reduce loss and

3) Fungicidal Spray :Spraying 1 % Bordeaux Mixture or 0.3 per cent copper oxychloride during monsoon twice at 45 days interval.

2)Charcoal rot (*Botryodiplodia theobromae* and *Macrophoma* Spp):

Season : More during summer, though it is seen through out the year.

Part affected : pods

Symptoms : Pods of all ages are susceptible. The affected pods turn black and remain hanging down on the tree as mummified fruit. Even beans inside the fruit turns black due to rotting of internal tissues. Soot (Charcoal/ black) of spore massed is formed**.**

Control: Spray 1 % Bordeaux Mixture.

Other diseases include cherelle wilt, pink disease, white thread blight, etc.

Question bank

1. Botanical name of cocoa is ---------- (*Theobroma cocoa*)
2. Large scale cultivation of cocoa in India strated during ---------- (1970's)
3. Write about microclimatic requirement of cocoa
4. Differentiate Criollo and Forestero types of cocoa
5. Write about the planting of cocoa as a mixed crop with coconut

LECTURE 32

Pests: Symptom of attack and control/management of i) Stem borer and ii) Mealy bugs.

Sl. No.	Name of the pest	Season of incidence and method of damage/ Symptoms	Management/ Control measuers	Remarks
1	Stem borer (*Zeuzera coffeae* Nietn.)	Bores into the branches and trunks of cocoa trees.	Prune and destroy the affected branches and take up prophylactic spray to the plant with 1.7ml dimethoate or 2ml Quinolphos or 4g Carboryl per litre of water. It can also managed by local application of carboryl paste after pruning the affected portion of stem.	Caterpillars of this polyphagus pest commonly known as red borer or coffee borer
2	Mealy bugs (*Planococcus lilacinus* Ckll.)	Adult and young ones suck tender shoots, cushions, flowers and pods, etc. They also cause cushion abortion and wilting of cherelles. Season : More during summer.	:Spot application of 1.25 ml of monocrotophos or rogor 1.70 ml per litre of water. If there is recurrence of the pest repeat the application after 30 days	Most important pest of cocoa in India is mealy bugs.

Harvesting, fermentation and yield of cocoa.

Harvesting :

Flowering : 2nd year after planting

Flowering to pod development : 140 to 160 days

Stage of harvesting : Ripe pods without damaging the flower cushions.

Maturity symptoms :

1) Distinctive Colour : In forestero green pods will become yellow when on ripening.

2) Rattling sound of beans : Seeds which are 25 to 45 in number rattle on ripening.

Harvesting intervals : 10 -15 days

Harvesting season :

Under South Indian conditions

1) September to January (Post monsoon)

2) April to June (Pre monsoon)

Off season crops are seen almost through out the year especially under irrigated conditions.

Note : Care should be taken not to damage flowering cushion at the time of harvesting of cocoa as it will produce the flowers and fruits of subsequent harvests**.**

Gap between harvesting and breaking of pods for processing : two days. (2-3 days). Break the pods cross wise and remove placenta along with husk and collect beans.

Pods can be kept upto a week before breaking and extracting the beans for fermentation.

Processing of cocoa :

Harvesting of cocoa consists of picking and breaking of ripe pods, removing the beans and transporting them for fermentation and drying.

Only ripe pods are harvested ----- Kept for minimum period of 2 days before opening the pods for fermentation (Should not be kept beyond 4 days). ---------Break the pods ----------collect beans for fermentation.
What for fermentation is essential in cocoa ?

Purpose of fermentation in cocoa includes;

1) To remove the adhering mucilaginous pulp,

2) To develop chocolate flavor and aroma precursors and to reduce bitterness,. Chocolate flavor is developed by the process of fermentation and drying at producer level and roasting them by manufacturer. The correct fermentation of cocoa beans is very important since, no subsequent process will correct the bad effect created at this stage.

3) To kill the germ (reproductive cells) of the seed and to loosen the testa.

4) To loosen testa and cause cotyledons to spread out.

Process of fermentation in cocoa:

It involves keeping the mass of cocoa beans immediately after taking out of the pods. Proper insulation for retention of temperature and adequate facilty for aeration of beans and drainage the sweat liquor is given.

Process of fermentation lasts for about 6 days (in Forestero type) during which period the pulp or mucilage adhering to the beans dis-appear and cotyledons changes its colour. Eg. In Forestero colour changes from purple or violet to dark chocolate brown.

Methods of fermentation

Fermentation

Fermentation of Cocoa beans is essential to remove the mucilaginous pulp, to develop flavour and aroma precursors, reduce bitterness, kill the germ of the seed and to loosen the testa. Among the various methods adopted for fermentation in different cocoa producing countries, Heap, Box Tray and Basket methods are considered as the standard methods.

TOP

Heap Method

This method involves keeping a mass of not less than 50 kg. of wet beans over a layer of banana leaves. The banana leaves are spread over a few sticks to keep them a little raised over the ground level to facilitate the flow of sweating. The leaves are folded and kept over a heap of beans and a few wooden pieces kept over it to keep the leaves in position. The heaps are dismantled and the beans mixed the third and fifth days. It needs about six days for the completion of fermentation and the beans can be taken out for drying on the seventh day.

Even though the minimum quantity of beans required for effective fermentation is 50 kg. a further increase in quantity of beans in a heap will be beneficial. However, heaps of more than about 500 kg. may be difficult to handle.

Tray Method

Wooden trays of size 90 cm x 60 cm x 13 cm with battens or reapers fixed at the bottom with gaps in between, are filled with beans. Each tray can contain about 45 kg. wet beans. Six such trays are stacked one over the other and an empty tray is kept at the bottom to allow for drainage of sweating. After stacking, the beans of the top most tray are kept covered with banana leaves.
After 24 hours of setting the stack of trays is kept covered with gunny sacking to conserve the heat that develops. There is no need for mixing the beans and fermentation will be completed in four days. On the fifth day the beans can be taken out for drying.

The minimum number of trays required to be stacked is about six but as many as 12 trays can be used simultaneously.

Box Method

Wooden boxes of 1.2 x 0.95 m x 0.75 m with holes at the bottom and sides of the box are filled with wet beans. These boxes can hold one M.T. of wet beans. The beans are to be mixed on alternate days. As the quantity of beans is high, this is best done by changing the beans from one box to another at the time of mixing. This would necessitate having a minimum of three boxes.

Wet beans taken for fermentation should be sufficiently ripe so as to separate the beans form the polacuta and husk easily. Minimum quantity of wet beans for a normal fermentation is about 100 kg. The

duration of fermentation is commonly for 3-5 days i.e., 72-120 hrs. Fermentation over 120 hours will cause loss of chocolate flavour and development of off flavour.

Drying & Storage

The fermented beans can be dried either in the sun or by artificial means. Sun drying can be done in thin layers of 2 - 3 cm. depth and stirring from time to time. When the beans are dried properly, they produce a characteristic cracking sound on compressing a fistful of beans in the palm. The more scientific method is to use moisture meter. The dried beans after cooling maintaining 6 -8% moisture should be cleared before storage. The fruit broken, shriveled and other extraneous material are removed. The cleared bags are kept on a raised platform of wooden planks.

However, box and basket methods are recommended.

What ever be the method adopted care must be taken

1) Immediate fermentation : To put the beans for fermentation immediately after taking out of the pods.
2) Proper insulation : Fermentation mass need to be provided with proper insulation for retentation of temperature
3) Proper facility for aeration of bean : Adequate facility for aeration beans must be made.
4) Drainage of sweat liquor.

Differences between box method and basket methods of cocoa fermentation;

Sl. No.	Particulars	Box method	Basket method
1	Minimum Quantity of beans required/Suitability	Large estates (40 to 100 kg)	Small quantity of beans (5 to 10 kg)
2	Method used	Wooden box of 60 cm x 60 cm x 45 cm with reapers at the bottom.	Bamboo or cane baskets of suitable size. Banana leaves at the bottom with provision for drainage of sweating.
3	Mixing process (To obtain uniform fermentation and to maintain temperature, moisture and aeration)	While transferring to next box after 24 hours	Mixed thoroughly on 3 rd and 5 th day

Yield: 20 to 35 kg ripe pods per tree or 100 - 131 pods per plant. Each pod will have 25- 45 beans. Dry beans per plant : around 2 kg In arecanut plantation the population per ha is around 686 plants and it will yield about 6q. dry beans per ha (i,e., about one kg dry beans per tree) High yielding clonal planting materials which have a production potential= 3 kg dry beans/tree.

Question Bank

1. Mention the major pests of cocoa
2. Mention the stage of harvesting and maturity symptoms in cocoa
3. Write about the purpose of fermentation in cocoa
4. Write a note on methods of fermentation in cocoa
5. Harvesting interval suggested in cocoa is ---------- (10-15 days)

LECTURE 17

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

Family = Arecaceae /i.e.,Palmae,

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

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

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

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

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

OIL palm research in India

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

Origin of Oil palm

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

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

LECTURE 17

It is available in wild, semiwild and cultivated forms in

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

Distribution of oil palm

World :

Regions: South East Asia,
West Africa,
Latin America

With 30 countries

Countries growing oil palm

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

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

  Area and production of oilpalm in world

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

LECTURE 17

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

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

Oil palm in India

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

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

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

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

1971-81 : Oil palm attained commercial status in India

1995 : Establishment of NRC on Oil palm

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

AP : Krishna, East Godavari and West Godavari

Karnataka : Shimogga

Maharastra : Sindhadurga Dist

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

Potential area that can be brought under oilpalm in India

LECTURE 17

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

- 80,000ha of which
  - AP = 50,000 ha : Especially in coastal Dist of AP
  - Karnataka = 20,000 ha

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

  and
  - Tamil Nadu =8,000 ha
  - Other states(Gujarat, Orissa, WB, Assam and Tripura) =Remaining area.

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

Need for large scale oil palm cultivation in India

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

Oil requirement

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

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

World average : 12 kg/head/year

LECTURE 17

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

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

3. Economic importance of oil palm :

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

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

e. Suitable for sustainable agriculture,

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

LECTURE 17

Constraints in the development of oil palm in India.

(In identified irrigated project areas)

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

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

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

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

Question bank

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

LECTURE 18

Soil and climatic requirement

Soil:

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

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

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

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

Sex ratio in oil palm

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

Sex ratio = No. Of female inflorescence X100

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

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

Varieties in oil palm

1) Dura : Have low to medium mesocarp (35 t0 55 %) and it contains a thick shell around the kernel . It is not preferred for commercial cultivation. Shell thickness

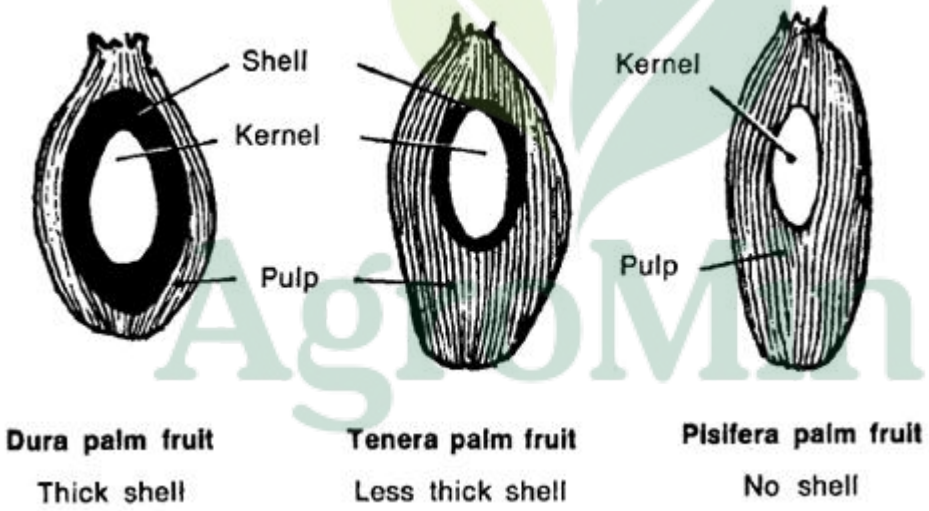
LECTURE 18

Mesocarp = 35- 55 % (54 % by weight),
Shell = 30% by weight
Kernel= 16 % by weight
Shell thick ness = 2 to 8 mm

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

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

Mesocarp = 60 to 95 % (74 % by weght)
Shell = 10 % by weight
Kernel = 16 %



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

LECTURE 18

Mesocarp = 90 % by weight

Kernel = 10 %

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

Table: Features differentiating fruit types of oil palm,

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

Type of progenies as a result of

a) Durra x Pisisfera b) Dura x Dura c) Tenera x Tenera

Dura = $Sh^+ Sh^+$

Tenera = $Sh^+ Sh^-$,

Pisifera = $Sh^- Sh^-$

Propagation in oil palm :

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

Mode of Propagation : Seeds

Planting and after care:

Planting:

Season : May – June,

Method/ System of planting :

Systems of planting: Generally square and

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

LECTURE 18

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

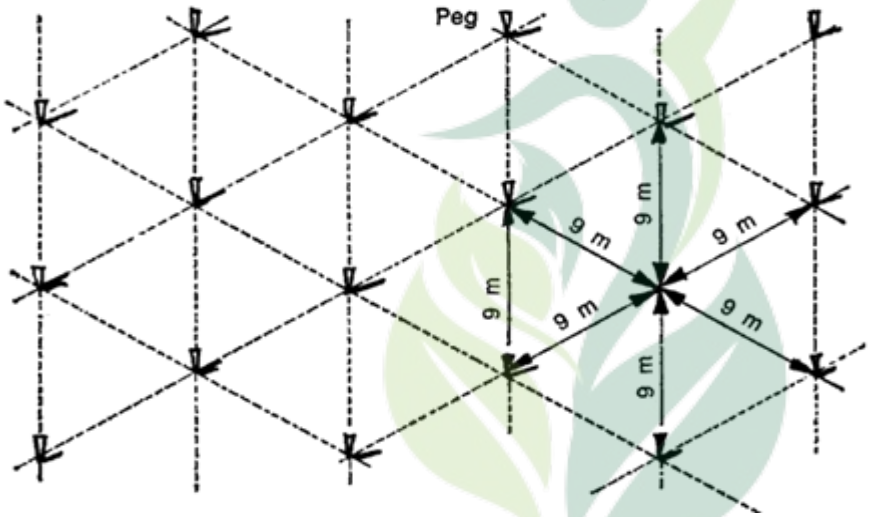
Pit size : 60 cm x 60 cm x60 cm

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

Or

10 m x 10 m.

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



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

Manuring :

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

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

LECTURE 18

Fertilizers:

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

Season→	May – June(Pre monsoon)			Sept- October(Post monsoon)			
Fertilizer → / Age↓	N	P_2O_5	$MgSO_4$	N	P_2O_5	K_2O	$MgSO_4$
Before Planting	---	125	----	----	-----	----	---
I Year	200	100	200	200	100	200	125 g
II Year	400	200	400	400	200	400	250g
III yr. And above	600	300	600	600	300	600	500g

Full dose for adult palm includes: 1200g N, 600 g P_2O_5 and 1200 g K_2O per year.

Deficiencies of micronutrients in Oil palm

Mg and Boron deficiency has been observed in Oil palm

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

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

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

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

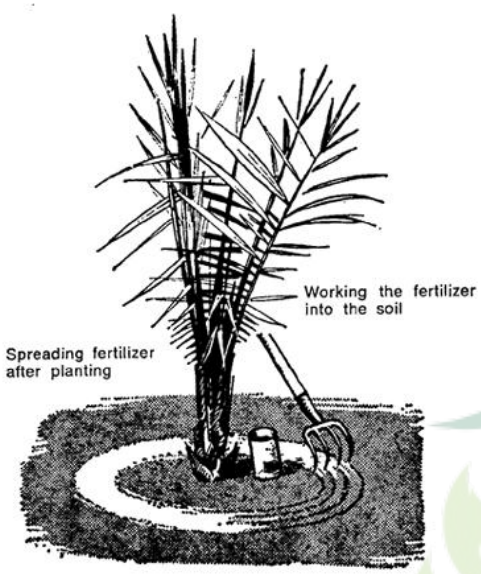
Note:

1)

- Supply Mg (@500g per palm per year) if deficiency symptoms are noticed.
- Borax @ 100 g per palm per year if boron deficiency is observed.

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

Method of fertilizer application in oil palm :



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

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

Basin management /Size of palm basin in oil palm

Widen the basin as and when tree grows.

I year of planting : 1 m radius

II year of planting : 2 m radius

III year and above : 3 m radius.

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

Note :

1) Spread fertilizer in the ring underneath the largest leaves and after spreading cover with a thin layer of soil.

2) If plants are mulched, remove the mulching material and spread fertilizer and spread a fresh mulch of dry herbage to a thickness of 15 to 20 cm.

LECTURE 18

Irrigation

Irrigation at the rate of 100 liters of water per palm per day (100 to150 liters per palm per day and even upto 200 liters per palm per day in hot summer) has to be provided during dry period to realize the yield potential of the palm.

Yield increase in oil palm under irrigation is attributed to;

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

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

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

Cover cropping

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

Seed rate : 2 to 3 kg per ha

Establishment of cover crops

Seed treatment:

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

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

LECTURE 18

Leaf Pruning in oil palm

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

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

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

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

If pruning of frond has not been attended it results in

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

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

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

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

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

Ablation in oil palm :

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

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

- Dis budding,
- Debudding,
- Deflowering

LECTURE 18

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

Purposes of ablation:

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

Period of ablation:

14 to 26 months after planting. Ablation can be commenced after about14 months of field planting and continued till 26 months when about 70 per cent of palms are producing inflorescences (at an interval of 4 to 5 months = ?)

Question Bank

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

LECTURE 19

Management / Control of Rodents Damage in oil palm

Rodents / rat damange

Control/ Management :

1) Trapping : Different baits such as Iron Live traps, Snap traps, Death fall traps, Bow trap, Cage trap, Spring death trap, Bamboo nose Trap may be used to minimize rat damage.
2) Orchard Sanitation
3) Poison Baiting :

   Acute rate poison : Rodenticides such as Zinc phosphoid, single dose anticoagulants like Bromadiolone ((0.005%)

   Multiple Dose anticoagulant rodenticides : Warfarin, Fumarin are placed in the field in the evening and removed in the morning

   Dead rats should be buried to avoid secondary poisoning
4) Mechanical Barriers : Oil palm seedling at the time of planting can be covered with 22 gauge galvanized iron (Chicken) wire mesh around bole as prophylactic measure against rats, porcupines etc
5) Biological agents :

   Predators for rats includes a) Snacks, b) Vultures, c) Mongoose d) Cats and e) Dogs.

Diseases in oil palm

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

(1) Spear rot:

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

Cause :

1) Several micro organisms are associated with this disease and most common ones are Fungi viz.,

Fusarium moniliformae and *Collatotrichum gloesporioides*

2) MLO and 3) Bacteria

LECTURE 19

Symptoms:

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

The chloratic area later turns brown and dries up.

Management: In view of uncertain etiology

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

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

Disorders in oil palm

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

Cause : Not specifically known

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

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

Harvesting, Processing and yield in oil palm:

Pre bearing age in oil palm : 3 years

Economical life : 25 years

LECTURE 19

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

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

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

Stage of harvest:

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

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

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

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

LECTURE 19

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

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

Harvesting interval :

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

Harvesting tools:

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

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

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

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

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

LECTURE 19

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

Processing for palm oil extraction:

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

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

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

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

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

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

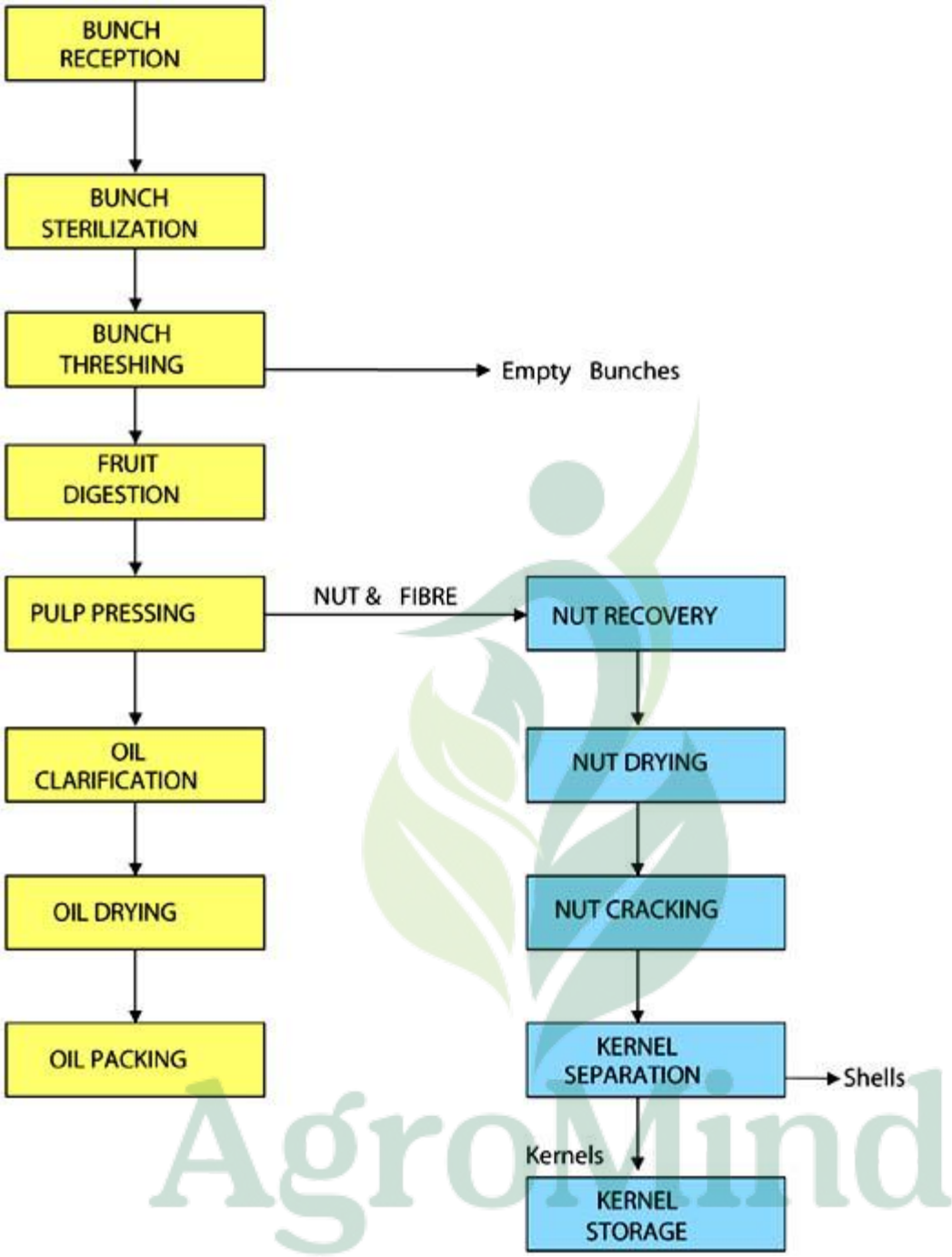
Fruit bunches are to be processed with in 24 hours of harvesting. If at all it has to be stored, it has to be sterilized and stored

Sterillization of FFB: After harvesting bunches are sterilized at 130 ºC for one hour under pressure of 2 kg per cm^2.

Stages of processing

PALM OIL PROCESSING UNIT OPERATIONS

LECTURE 19



Sterillization brings about

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

LECTURE 19

2) Stripping: Fruits are separated from the bunches.

How?

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

How ?

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

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

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

Palmolein has thick consistency , red colour,

Production of Edible oil

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

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

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

Yield:

LECTURE 19

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

Average number of buches per palm = 10 to 12

Average bunch weight : 30 to 40 kg /buch

Average FFB yield per year per ha = 12 tonnes

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

Under good management

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

Question bank

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