SPICES AND CONDIMENTS

HPH 204

2. Spices and Condiments (HPM 200) 3 (2+1)

History, scope and importance, area and production, uses, export potential and role in national economy. Classification, soil and climate, propagation-seed, vegetative and micropropagation systems and methods of planting. Nutritional management, irrigation practices, weed control, mulching and cover cropping. Training and pruning practices, role of growth regulators, shade crops and shade regulation. Harvesting, post-harvest technology, packaging, storage, value added products, methods of extraction of essential oil and oleoresins. Economics of cultivation, role of Spice Board and Pepper Export Promotion Council, institutions and research centers in R&D. Crops: Cardamom, pepper, ginger, turmeric, clove, nutmeg, cinnamon, all spice, curry leaf, coriander, fenugreek, fennel, cumin, dill, celery, bishops weed, saffron, vanilla, thyme and rosemary.

Practical: Identification of varieties: propagation, seed treatment – sowing; layout, planting; hoeing and earthing up; manuring and use of weedicides, training and pruning; fixing maturity standards, harvesting, curing, processing, grading and extraction of essential oils and oleoresins. Visit to commercial plantations.

Lecture 1, 2 & 3

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 spice-producing, exporting and importing countries of the world.

Definition of Spices and Condiments:

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. 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.

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.

Brief history of Spices:

The utilization of spices known since the beginning of human civilization. In medieval times, the word ‘India’ 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 that 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, 4 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 (Fig.1.1). 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 voyage!

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:

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 recognised by the International Organization for Standardization (ISO) world more than 52-60 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 finds 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 endowed with favourable 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 it's products are used as whole and powder form. Essential oils and oleoresins are widely used in seasoning of foods and imparting aroma, flaovur 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 colourant or die 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.

Present Status of Indian Spice Industry:

Area and production:

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. The area and production of important spices in India are given in Table 1.

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 (3 to 4 t/ha).

TABLE – 1 CROP-WISE AREA, PRODUCTION AND PRODUCTIVITY OF MAJOR SPICE CROPS IN INDIA DURING 2007-08, 2008-09 AND 2009-10 Area in 000 HA, Production 000 MT and Productivity = MT/HA

	2007-08			2008-09			2009-10		
	AREA	PRODUCTION	PDY.	AREA	PRODUCTION	PDY.	AREA	PRODUCTION	PDY.
Chillies	808.17	1294.15	1.6	779.05	1269.85	1.6	767.23	1202.94	1.6
Garlic	206.12	1068.50	5.2	166.21	831.10	5.0	164.86	833.97	5.1
Turmeric	174.51	794.19	4.6	181.09	821.16	4.5	180.96	792.98	4.4
Ginger	104.36	390.08	3.7	108.64	380.10	3.5	107.54	385.33	3.6
Coriander	384.21	229.95	0.6	396.85	242.13	0.6	360.00	236.72	0.7
Tamarind	55.04	182.08	3.3	54.63	177.68	3.3	57.99	185.46	3.2
Cumin	429.38	172.47	0.4	429.38	172.47	0.4	377.01	156.33	0.4
Fenugreek	55.20	55.48	1.0	68.29	76.58	1.1	43.25	57.44	1.3
Fennel	54.29	67.78	1.2	47.16	64.29	1.4	50.67	56.55	1.1
Pepper	197.33	47.01	0.2	238.71	47.40	0.2	195.92	51.02	0.3
Cardamom	81.93	13.65	0.2	91.99	15.45	0.2	90.20	15.72	0.2
Other seed spices	17.71	10.71	0.6	17.71	10.71	0.6	19.36	13.04	0.7
Ajwan	19.29	11.12	0.6	19.59	16.41	0.8	17.06	10.27	0.6
Nutmeg	15.26	11.37	0.7	15.27	11.37	0.7	15.05	8.00	0.5
Tejpat	2.45	5.29	2.2	2.44	4.98	2.0	3.24	7.08	2.2
Cinnamon	0.87	1.67	1.9	0.88	1.67	1.9	1.00	1.67	1.7
Clove	2.25	1.01	0.4	2.57	1.33	0.5	2.60	1.16	0.4
Others (2)	9.01	0.23	0.03	9.01	0.23	0.03	9.34	0.24	0.03
Total	**2617.36**	**4356.71**	**1.7**	**2629.44**	**4144.91**	**1.6**	**2463.29**	**4015.91**	**1.6**

Figure1

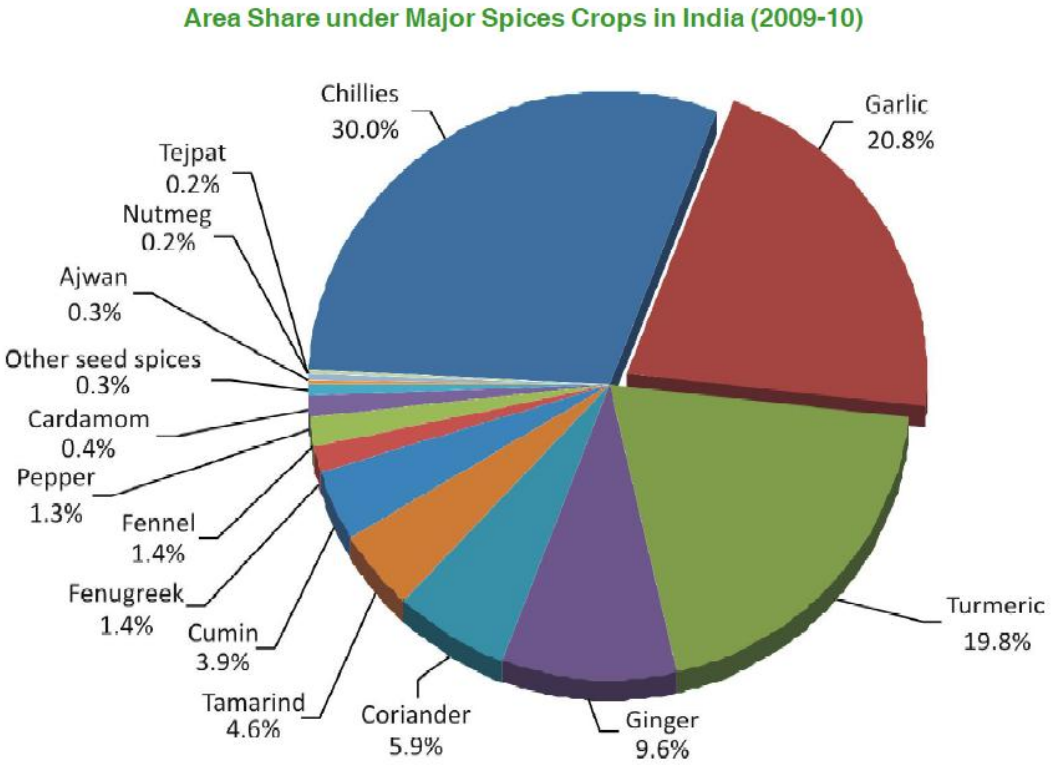

Area Share under Major Spices Crops in India (2009-10)
Chillies 30.0%
Garlic 20.8%
Tejpat 0.2%
Nutmeg 0.2%
Ajwan 0.3%
Other seed spices 0.3%
Cardamom 0.4%
Pepper 1.3%
Fennel 1.4%
Fenugreek 1.4%
Cumin 3.9%
Tamarind 4.6%
Coriander 5.9%
Ginger 9.6%
Turmeric 19.8%

Table – 2, STATEWISE AREA, PRODUCTION 7 PRODUCTIVITY OF MAJOR SPICES IN INDIA Area in 000 HA, Production in 000 MT and Productivity = MT/HA

	2007-08			2008-09			2009-10		
	AREA	PRODUCTION	PDY.	AREA	PRODUCTION	PDY.	AREA	PRODUCTION	PDY.
Andhra Pradesh	318.52	1235.12	3.88	318.40	1225.29	3.85	312.52	1159.67	3.71
Rajasthan	579.50	534.03	0.92	567.40	471.76	0.83	489.65	437.18	0.89
Gujarat	320.05	518.15	1.62	306.99	426.61	1.39	266.31	400.85	1.51
Karnataka	229.04	325.61	1.42	233.48	341.65	1.46	217.66	303.24	1.39
Madhya Pradesh	192.17	275.77	1.44	197.01	250.41	1.27	197.11	236.27	1.20
Tamil Nadu	137.90	264.84	1.92	125.08	235.13	1.88	125.09	235.01	1.88
Orissa	147.00	199.20	1.36	146.72	198.22	1.35	146.72	198.22	1.35
West Bengal	94.40	185.80	1.97	95.87	188.40	1.97	95.87	188.40	1.97
Uttar Pradesh	59.11	194.90	3.30	56.48	170.06	3.01	54.83	163.02	2.97
Kerala	261.88	128.17	0.49	301.07	126.24	0.42	264.39	136.03	0.51
Maharashtra	114.00	97.00	0.85	113.64	96.57	0.85	113.64	96.57	0.85
Mizoram	9.00	38.30	4.26	22.67	80.62	3.56	22.67	80.63	3.56
Meghalaya	16.64	71.25	4.28	16.60	69.91	4.21	17.41	72.01	4.14
Punjab	5.15	23.69	4.60	5.15	23.69	4.60	17.53	66.68	3.80
Arunachal Pradesh	9.20	53.10	5.77	7.63	43.34	5.68	7.63	43.34	5.68
Sikkim	20.60	43.20	2.10	26.58	41.73	1.57	26.58	41.73	1.57
Nagaland	4.50	26.20	5.82	7.22	38.62	5.35	7.22	38.62	5.35
Haryana	6.75	24.84	3.68	5.15	24.52	4.76	5.15	24.52	4.76
Hima. Pradesh	7.60	23.60	3.11	4.44	18.62	4.19	4.44	18.62	4.19
Assam	28.63	18.76	0.66	27.37	18.55	0.68	27.37	18.55	0.68
Uttaranchal	9.26	24.42	2.64	1.94	13.06	6.73	1.94	13.05	6.72
Bihar	11.60	13.70	1.18	11.28	12.36	1.10	11.28	12.36	1.10
Tripura	4.20	13.70	3.26	4.50	10.28	2.28	3.96	12.10	3.06
Manipur	10.98	8.22	0.75	8.98	7.84	0.87	8.98	7.84	0.87
Chhattisgarh	12.86	10.51	0.82	11.56	7.18	0.62	11.56	7.18	0.62
A & N Islands	1.70	3.12	1.84	1.66	3.15	1.90	1.66	3.15	1.90
J& Kashmir	4.39	1.31	0.30	3.89	0.91	0.23	3.89	0.91	0.23
Goa	0.70	0.20	0.29	0.65	0.17	0.26	0.65	0.17	0.27
Pondicherry	0.02	0.00	0.00	0.02	0.03	1.23	0.02	0.03	1.23
Total	**2617.36**	**4356.71**	**1.66**	**2629.44**	**4144.91**	**1.58**	**2463.73**	**4015.93**	**1.63**

Table – 3, ALL INDIA - AREA PRODUCTION AND PRODUCTIVITY OF SPICES

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 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 rose to 15,720 tonnes in 2009-10. 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 2009-10. During 2009-2010, the area under the crop was 7.67 lakh hectares with a production of 12.02 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 (1.80 lakh hectares), production (7.92 lakh tonnes) and productivity (4,400 kg) was recorded in 2009-10. The annual growth rate is encouraging in the last five years. The price of turmeric had plummeted to around Rs.26 kg during 2000-01. The lucrative price of Rs.16,000/quintal was recorded during 2009-10, 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 1.64 lakh hectares with a production of 8.33 lakh tonnes (2009-10). The price of garlic has rose 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 21,590 hectares which went up to 77,600 hectares in 1999-00 and 1,07,000 hectares in 2009-10. 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 antiobesity factor and pro-hydroxy citric acid

in the fruit rind. The area under nutmeg is 15,000 hectares with an annual production of 8,000 tonnes; while for clove, the area and production are 2,600 hectares and 1,160 tonnes, respectively. Cinnamon occupies an area of 1,000 hectares with a production of 1,000 tonnes during 2009-10.

The production of spices in the country has increased by 22 lakh tonnes during the IX Five Year Plan to 40.50 lakhs tones during 2009-10.

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.

Export:

The changed economic scenario order in the context of globalisation and liberalisation 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 40-50% 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 exports

18,850 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 313-92 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 tonees 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.

Table – 4 - Export of spices from India

ITEM-WISE EXPORT OF SPICES FROM INDIA (QTY. IN TONNES & VALUE IN Rs. LAKHS)												
	2005-06		2006-07		2007-08		2008-09		2009-10		2010-11 (E)	
ITEM	QTY	VALUE	QTY	VALUE	QTY	VALUE	QTY	VALUE	QTY	VALUE	QTY	VALUE
PEPPER	17,363	15094.81	28,726	30599.18	35,000	51950.00	25,250	41373.50	19,750	31392.50	18,850	38318.50
CARDAMOM(S)	863	2682.13	655	2348.10	500	2475.00	750	4726.50	1,975	16570.25	1,175	13216.25
CARDAMOM(L)	1,046	1154.65	1,504	1700.08	1,325	1500.00	1,875	2280.75	1,000	1788.60	775	4462.90
CHILLI	113,174	40300.51	149,022	80855.99	209,000	109750.00	188,000	108095.00	204,000	129172.80	240,000	153554.00
GINGER	9,411	4295.52	7,535	3883.05	6,700	2800.00	5,000	3482.50	5,500	4675.00	15,750	12131.25
TURMERIC	46,405	15286.02	51,712	16575.98	49,250	15700.00	52,500	24857.75	50,750	38123.00	49,250	70285.15
CORIANDER	23,756	6770.73	21,389	7959.49	26,000	11025.00	30,200	20378.75	47,250	22585.50	40,500	16663.25
CUMIN	12,879	9819.07	26,042	20224.12	28,000	29150.00	52,550	54400.00	49,750	54824.50	32,500	39597.75
CELERY	4,165	1500.64	4,294	1563.36	2,900	1325.00	3,650	2333.00	5,000	2662.50	3,750	2585.90
FENNEL	5,725	2782.33	5,305	3579.64	5,250	2850.00	8,675	4315.00	6,800	5623.60	7,250	6588.25
FENUGREEK	15,525	3402.87	8,616	2710.89	11,100	3300.00	20,750	7175.25	21,000	6972.00	18,500	6548.10
OTHER SEEDS (1)	12,670	3321.99	12,906	3678.58	8,850	3125.00	17,500	6498.50	15,500	5890.00	12,500	5558.05
GARLIC	34,688	4798.38	13,598	2713.43	675	400.00	760	350.25	10,750	3042.25	17,300	6977.30
TAMARIND	14,101	3078.20	17,882	4138.32	11,250	3100.00	11,500	4105.00	12,200	4705.50	17,500	8000.00
NUTMEG & MACE	1,530	3117.21	2,042	4264.27	1,300	2875.00	2,155	6074.75	3,275	9186.50	2,100	9776.80
VANILLA	72	1226.80	126	2062.67	200	1775.00	305	2670.00	200	2251.50	175	1874.50
OTHER SPICES (2)	7,033	4414.57	8,776	6136.53	7,750	5000.00	8,500	6459.00	8,000	7818.50	7,575	6140.80
CURRY POWDER	9,340	7838.03	9,373	8586.07	11,500	11100.00	13,250	16375.00	14,300	18918.50	15,250	21050.50
MINT PRODUCTS (3)	14,544	81320.66	17,642	120908.97	21,100	128050.00	20,500	142025.00	19,000	118972.00	17,450	169679.00
OILS & OLEORESINS	6,074	50557.34	6,546	56116.04	6,600	56300.00	6,850	72050.00	6,750	70875.00	7,600	91062.45
TOTAL	350,363	262762.45	393,692	380604.75	444,250	443550.00	470,520	530025.50	502,750	556050.00	525,750	684070.70
VALUE IN MILLION US $		592.90		844.03		1101.80		1168.40		1173.75		1502.85

(1) INCLUDE BISHOPS WEED(AJWANSEED), DILL SEED, POPPY SEED, ANISEED, MUSTARD ETC.
(2) INCLUDE ASAFOETIDA, CINNAMON, CASSIA, CAMBODGE, SAFFRON, SPICES (NES) ETC.
(3) INCLUDE MENTHOL, MENTHOL CRYSTALS AND MINT OILS.
SOURCE : DGCI&S., CALCUTTA/SHIPPING BILLS/EXPORTERS' RETURNS.

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. Non-adoption of manuring and balanced fertilizers.
4. Non adoption of recommended cultural practices, as well as soil and water conservation measures.
5. Non adoption of integrated pest and disease management practices.
6. Inadequate extension network for effective transfer of technology.
7. High fluctuations in prices of the commodities and the absence of a support price.

Quality Assurance Mechanism:

Even though India has been in the forefront for export of spices for several centuries, it was not until the mid-80s that the word 'quality' assumed importance. The imposition of quality standards by importing countries resulted in efforts for quality assurance. The steps were taken by the Spices Board to develop and inculcate good post-harvest management right from the stage of harvesting—particularly in seed spices. The right stage of harvest decides the quality, viz., size, colour, fibre content, volatile oil, chewing quality (fennel), splitting (coriander), etc. Clean drying. proper winnowing to remove dirt, chaff, plant parts, birds' droppings, rat excreta, hair, etc., followed by storage in hygienic and well-ventilated godowns ensures a good product. At the international level there is a stringent quality standard which has to be met by exporting countries. The specifications of American Spices Trade Association (ASTA) and the International Organisation for Standardisation (ISD) guidelines, with mutually agreed terms are followed. Japan and many other countries use the ASTA specifications; India, Malaysia, Spain, Indonesia, Sri Lanka and Hungary have their own quality standards for exporting spices. ASTA specifications are for unprocessed spices imported into the USA, and they regulate the cleanliness of these spices. ASTA specifications place limits on extraneous matter (insects, insect excrement, stones, stems, sticks, moulds, etc.) and set standards in sampling and testing procedures. Imported spices not meeting these specifications are reconditioned at the port of entry, while local spices need to be reconditioned (using fumigants) before they are processed for use in a product.

The US Federal Specifications establish quality standards for whole and ground spices. Specifications include total ash, acid-insoluble ash, volatile oil, moisture, colour and granulation, and these are standardized for the major spices. These specifications have

maxima or minima values that differ considerably between importing countries. Standards for defective spice (stalks, stems or other contaminants) are also established. The ISO has specifications for most spices, such as extraneous matter, moisture content, total ash, acid-insoluble ash and other chemical characteristics. Based on the ISO, Britain and Canada have established their own standards. Spices that are irradiated, reheated with ethylene oxide or contaminated with aflatoxin are prohibited under the Japanese Sanitation Law.

In India, quality standards are established for unprocessed and processed spices that particularly regulate moisture content, volatile oil, total ash, acid-insoluble ash, starch and extraneous matter. Grades are also established with specifications. Many spices, such as turmeric, black pepper, ginger and chilli peppers, have individual grade specifications that differentiate them from similar spices. Even curry powders are graded based on the amount of spices and salt they contain. Similar specifications are established for spices in many other countries.

Grinding and sterilizing procedures decrease the volatile oils in spices. Excessive heat volatilizes and dissipates the essential oils in ground spices, and high humidity tends to cake them. Exposure to light, humidity variations, air and certain metals can discolor many spices such as paprika, turmeric or the green leafy spices. Dry, ground chilli peppers turn from a natural green or red colour to an olive or dirty reddish-brown colour when exposed to light. Flavour and aroma losses, as well as insect and rodent infestation, occur when spices or spice extracts are stored in tightly closed containers in cool, dark, dry conditions below 4.4°C and 60% humidity. Some spices need storage at low temperatures of about 2-5°C to prevent mould infestation (capsicum peppers), colour deterioration (paprika) and to avoid rancidity (in high fixed oil seeds, such as sesame seeds). Colder temperatures also help preserve the volatile oil flavour and aroma, freshness and sanitary quality; refrigeration slows microbial growth. Whole spices tend to have better shelf life than ground spices. Ground spices for minimally processed foods such as salad dressings, condiments or 'sprinkle on' seasonings should be well cleaned and sterilised.

High levels of moisture in ground or whole spices indicate mould and microbial growth. During storage, insects breed on spices in varying degrees, depending upon storage conditions, where they are harvested, transportation contamination and the extent of cleaning. Filth levels include foreign materials such as insect fragments (moths, mites, beetles), small stones, metal fragments and glass pieces. Insects and mould growth can change the colour and, to some extent, the flavour of the spice.

Microbiological requirements for 'clean' spices include counts for total bacteria, yeast,

mould, coliforms and food pathogens such as *Eschersia coil* and *Salmonella.* High microbial counts are caused by contamination during growing and post-harvest handling. Spore-forming bacteria, such as the *Bacillus* species or *Aerobacter aerogenes* found in the soil can be transferred to the spice during the drying process, particularly to 'under the ground' spices such as turmeric, ginger, galangal or garlic. The type and amount of moulds and bacteria on a spice depends upon the type of spice and the conditions under which it is harvested and dried. *Staphylococcus* and *Streptococcus* species of bacteria predominate, but pathogenic bacteria tend not to exist on spices. Spices that show strong antimicrobial properties tend to have low counts of microbes. Moulds, such as *Aspergillus,* that produce the toxin Aflatoxin and *Penicillium,* are found on certain species including red pepper, fenugreek and ginger, so there are specification limits for these toxins. Moulds tend to multiply during the drying process and storage. The control of insects and microbes is important in receiving quality spices. Spices need to be free of microbes so as to reduce the initial bacteria or mould content in processed foods. Spice extractives and sterilised spices tend to meet these objectives. Organic foods are becoming more popular, and for food to be labelled as organic, irradiation is not permitted. Spices that are not sterilised can be potent sources for microbial contamination and growth.

Marketing:

The marketing of spices is mainly by middlemen and trade agencies. Only small extent Spice Board and Spice Trade promotion council perform the task. There is normally no government intervention in this trade, with regard to the marketing procedure or in the maintenance of a reasonable price for the farmers. Farmers dispose of their produce either locally to a village shop, cooperative society or even to a terminal market. The choice depends on a number of factors such as loyalty or financial obligations to a particular trader, the distance to the terminal market, the prevailing market price, etc. Marketing the produce to pre-harvest contractors is also in vogue in certain areas. In this case, the farmers receive an advance payment immediately after the acceptance of the offer. Collection centres operate within a short distance of the growing areas and also in almost every town. The merchants purchase from these centres when the price is quite attractive in the terminal markets. Commission agents receive the goods and sell them to the exporters through brokers and dealers. The exporters grade the finished product according to grade specifications and finally consign the packed material to the shipping agents. The important channels in the spices marketing are:

1. Producer – Village merchant /wholesaler – commission agent/exporter-Foreign importer

2. Producer-Village merchant/wholesaler-commission agent/wholesaler of cosuming market-retailer-consumer.

Of these two, the more important one for black pepper is the former channel, as the major share of the produce is being exported and the internal price is solely dependent on foreign demand.

At present there is no regulated market for spices in Kerala. However, the co-operative marketing societies in Kerala handle these commodities, but they are also not functioning very well. The main reason for their failure is their poor financial resources that makes them incapable of providing short term/long term loans to the farmers in time. In other states like Karnataka, where regulated marketing is in vogue, the farmers do not get their legitimate share.

Normally, the farm price a grower gets is much lower than the retail sale price in the assembling or distributing markets. This wide range of disparities in the price received by the producers is mainly due to:

1. Expenditure incurred in marketing.
2. Margin of profit enjoyed by the pre harvest contractors/intermediaries.
3. Deduction on account of high moisture percentage.
4. Incidence of various taxes and other charges.
5. Transportation costs, etc.

Challenges, thrust areas and research support and highlights:

- Low productivity of spices is the major issue to be addressed in the country. In black pepper, our national average is only 316 kg/ha whereas, in Thailand it is 3,352 kg/ha. Guatemala produces cardamom at the rate of 250 kg/ha as compared to 135 kg/ha produced in India. Ginger is about 3391 kg/ha in India as against 8,116 kg/ha in Indonesia. At present we do not have high yielding varieties, appropriate production technologies and a highly conductive climate for spices production.
- Quality is the key to good marketing of spices. Our motto should be 'clean spices' rather than 'cleaned spices'. In order to compete and retain our position in the world spices market, our ability to meet the quality expectations in the areas of pesticide residues, mycotoxins and microbial load should be strengthened.
- Broad-basing the spices export basket by product diversification to meet global quality standards.
- Price competition in the global market is another major challenge for the Indian spice industry. A realistic price reduction to offer healthy competition to our major competitors like

Vietnam (for black pepper), Guatemala (for cardamom). etc., should be seriously considered.

- Challenges with respect to the WTO regime and IPR issues.
- Many Indian spices are much valued in the world market because of their intrinsic qualities. However, the import of low grade spices to India and re-export under the Indian label should be regarded very seriously.
- Promotion of organic spices production, so as to cash in on the growing demand for organic produce in the world market. The huge expense involved in the process of certification remains a major challenge to be addressed.

Research Support:

Research schemes on spices were initiated in limited number during 1940s. Research on spices was initially restricted to formulate cultural practices for major spices like black pepper, cardamom, ginger and turmeric at a few centres under the Department of Agriculture in the Southern states comprising Kerala, Karnataka, Tamil Nadu and Andhra, Pradesh. Since 1949, there have been organised attempts to conduct spices research in the country and to formulate specific programmes for the development of spices. The Government of Madras initiated the first pepper research scheme at Panniyur, Kerala. It was followed by cardamom research schemes at Mudigere (Karnataka) and Pampadumpara (Kerala) in 1951. The Spices Enquiry Committee set up by the Government of India in 1953 made recommendations to commence specific research activities and the opening of new research centres on spices. Accordingly, research centres were set up at Chethalli (Karnataka), Dergaon (Assam) and Sirsi (Karnataka) for black pepper; Kandaghat (Punjab), Targaon (Maharashtra) and Thodupuzha, Ambalavayal (Kerala) for ginger and turmeric; and Burliar (Tamil Nadu) for minor spices. The pre-plan period included research schemes for cardamom in Chennai (Tamil Nadu), ginger in Kerala and Orissa and turmeric in Orissa. These programmes came to a natural end with the termination of their respective schemes. The first five year plan stressed research on pepper, cardamom, clove, nutmeg and minor spices. During the second and third plans, research on spices spread to a number of states including Orissa, Andhra Pradesh and West Bengal. Schemes for minor spices and vanilla were also initiated during this period.

To increase the production and productivity of spices, adequate research support is needed. The research and development work in spices is carried out by Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs), Spices Board, Directorate of Arecanut and Spices Development, Council of Scientific and Industrial Research (CSIR) and a few other agencies. The Indian Council of Agricultural Research is

the apex body that conducts, coordinates, manages and funds various crop research prcgrammes. The research and development of spices received new impetus and vitality when ICAR commenced concerted research through the All India Coordinated Research Project on Spices. The establishment of the All India Coordinated Spices and Cashew Improvement Project (AICSCIP) by the ICAR in 1971 (IV Plan) was a major step in spices research in the country.

During the fifth plan period, ICAR recognised the need to initiate concerted research on major spices like black pepper, cardamom, ginger, turmeric and tree spices. A regional station under CPCRI (ICAR) was started on 10th November, 1975 at Calicut, Kerala, to carry out research exclusively on spices. The Cardamom Research Centre at Appangala, Coorg, Karnataka, originally established by the Mysore Government to initiate research on cardamom, was taken over by CPCRI in 1974 from the Indian Institute of Horticulture Research,

Bangalore. This was followed by the setting up of the Indian Cardamom Research Institute in 1976 by the Spices Board to work exclusively on cardamom, with four regional stations.

The CPCRI (RS), Calicut, was upgraded and designated as National Research Centre for Spices (NRCS) in April 1, 1986, by merging the CRS, Appangala, Karnataka. The AICRPS, functioning from 1971, was bifurcated into two independent projects, one on spices and other on cashewnut, in September 1986. Based on the recommendations of the QRT and the parliamentary committee (Rajya Sabha), the NRCS was upgraded to a full-fledged institute and called the Indian Institute of Spices Research from July 1, 1995.

The AICRPS is the largest spices research network in the country, providing the much needed R & D base. Research on 12 mandate crops is carried out under the AICRPS in 20 coordinating centres, located in 15 states with the respective Agricultural Universities, representing the major agro-climatic regions.

Highlights of spice research:

- The IISR & AICRPS centres hold more than 10,500 germplasm accessions in black pepper, cardamom, ginger, turmeric, tree spices, seed spices and vanilla.
- The concerted efforts made during the last three decades resulted in the release of many high yielding varieties.
- Production technologies have been developed with respect to propagation, density of planting, manures and fertilizers, irrigation, cropping systems, harvesting, processing, grading and development of value added products.

- Integrated plant nutrient management systems are being evolved, weed management and water requirement have been standardised for a few spices.
- Advances have been made to locate sources of resistance/tolerance to biotic and abiotic stress.
- Technology for management of pests and diseases has been developed.
- Integrated disease management has been developed against major diseases.
- High quality lines in black pepper, cardamom, ginger and turmeric have been identified.
- Advances have been made in biocontrol of diseases in major spices.
- The production of planting materials have been undertaken.

Research attainments:

A considerable increase in productivity has been reported in research stations especially in pepper, ginger, turmeric and coriander.

The critical need is effective transfer of technology. Attempts are being made to identify main production constraints and work out appropriate and economic strategies.

An exclusive nucleus seed multiplication programme to supply quality planting materials to farmers is under implementation. Research results are available on the rapid multiplication through tissue culture of black pepper, cardamom, clove, nutmeg, cinnamon, ginger and turmeric.

Biotechnology research has great potential in spices *Potential applications of* plant *biotechnology in spices*

- Micro-propagation and rapid clonal multiplication of high yielding, elite genotypes to generate adequate good quality and disease-free planting materials. E.g. cardamom, vanilla, black pepper.
- Exploiting somaclonal variation and utilisation of techniques like somatic cell hybridization, anther culture, embryo rescue, etc., for crop improvement. E.g. bold rhizome types in ginger.
- In *vitro* selection for resistance to biotic and abiotic stresses. E.g. soft-rot resistant lines in ginger.
- In *vitro* selection for resistance to biotic and abiotic stresses. E.g. soft-rot resistant lines in ginger.
- In *vitro* conservation and safe exchange of germplasm.
- Production of flavour and volatile constituents in culture.
- Synseed technology available for many spices.

Spices	Constrains	Research attainment
Black pepper	Phytophthora foot rot	Management of the disease through package of practices is standardised. Tolerant lines to the disease are developed (P24), biocontrol is being recommended
	Stunt disease	No effective control measures except uprooting of diseased plants. Causative organism is virus/mycoplasma, insect, micronutrient deficiency
	Slow decline	Effective management method(s) are available except on source of resistance to *Radopholus similes* nematode.
	Low productivity	High Production Technology (HPT) is demonstrated
Small cardamom	Katte disease, Vein clearing (Kokke Kandu) virus diseases	Virus etiology is established. *'Katte'* escapes are identified. *Katte'-tolerant lines are multiplied
	Low productivity	Removal of diseased plants is advocated. No effective management measures are available. The spread has been checked by social action.
Ginger Turmeric	Rhizome rot	High Production Technology (HPT) is demonstrated. *Pythium* sp. involved, soil solarisation
	Bacterial wilt	Causitive organisms are identified. Solarisation of soil prior to planting is effective. Biocontrol is being tried out.
	Nematode infestation	*Ralstonia solancearum* is the causal organism. No resistant variety is available. *Meloidogyne* sp. and *Pratylenchus* sp. identified.
	Low curcumin	High curcumin lines have been identified.
	Low productivity	Integrated plant nutrient management (IPNM) has been developed.

Table 9 Improved variety and hybrid released so far

Spices		**Hybrids /varieties released**
Black pepper	16	Panniyur-1 (H); Panniyur-2 (V); Panniyur-3 (H); Panniyur-4 (V); Panniyur-5 (V); Panniyur-6 (V); Panniyur-7 (V); Subhakara (V); Palode-2 (V); Sreekara (V); Panchami (V); Pournami (V), IISR Thevam (V), IISR Malabar Excel (H), IISR Girimunda (H), IISR – Shakthi (V).
Small Cardamom	14	Mudigere-1 (V); Mudigere-2 (V); PV-1, PV-2 (V),; CCS-1 (Suvasini) (V); ICRI-1 (V); ICRI-2 (V); ICRI-3, TKD – 4 (V), IISR Vijetha (V), IISR Avinash (V), Njalani green gold (V), SKP-14) (V); ICRI-4 (V)
Cinnamon	8	IISR Navasree (V); IISR Nithyasree (V), YCD-1 (V), Konkan Tej (V), Sugandhini, PPI (C)-1 (V), RRL (v) C-1 (V).
Ginger	9	Suprabha (V); Suruchi (V); Surabi (V); Varada (V); Himgiri (V), V_3S_1-8, V_1E_8-2 (V), IISR Rejetha (V), IISR Mahima (V)
Turmeric	24	Co-1(M); Krishna (V); Sugandham (V); BSR-1 (V); BSR-2 (V); Suvarna (V); Roma (V); Suroma (V); Rajendra Sonia (V); Suguna (V); Sudarshana (V); Ranga (V); Rasmi (V); IISR Prabha (V); IISR Prathibha (V); Megha Turmeric-1 (V), Pant peethabh, Suranjana (V), Alleppy Supreme (V), IISR Kedaram (V), Kanthi (V), Sobha (V), Sona (V), Varna(V).
Coriander	21	Gujarat Coriander-1 (V); Co-1 (V); Co-2 (V); Co-3, (V); Gujarat Coriander 2 (V); Rajendra Swati (V); RCr-1 (V); RCr-41 (V); Sadhana (V)' Swathi (V); CS-287 (V); Sindhu (V); UD 20 (V); DH-5 (V); CIMPO S-33 (V); Hisar Anand (V); Pant Dhania (V); Sadhana, CS-2 (V),
Cumin	12	RS-1, S-404 (V); MC-43 (V); Gujarat Cumin-1 (V); Gujarat, Cumin-2 (V); RZ-19 (V), GC-3 (V) GC-4 (V) Selection – 3 (V), CJS- 182 (V), VC-19 (V), VC-198 (V).
Fennel	7	S-7-9 (V); PF-35 (V); Gujarat Fennel-1 (V); Co-1, (V), Gujrat Fennel-2 (V); Rajendra, Saurabh (V), UF-32 (V),
Fenugreek	14	Co-1 (V); Co-2 (V) Rajendra Kanti (V); RMt-1 (V); Lam Selection-1 (V), RMt 303 (V), RMt 143, Hisar Sonly (V) Gutarat Methi-1 (V); Rajendra Khushba (V), Pusa Early Bunching (V), Kasuri Selection (V), Prabhat (V)

H-Hybrid, V-Variety, M-Mutant *(Source:* Spice Board, Cochin)

Source: Spice Board, Cochin)

Table 10 - Methods of plant propagation in spices

Spices	Method of propagation	Advantages
Black pepper	Single noded rooted cutting using bamboo method,	Multiplication rate of 1:40 per year. Good anchorage due to presence of two root systems
	Serpentine method,	The recovery percentage is higher compared to rapid multiplication technique.
	Pit method.	Simple, less costly, quick and ready for planting within 4 - 4 ½ months
Cardamom	Trench method of sucker production.	Multiplication rate of 1:20 per year
Clove	Inarching on clove seedling.	Earliness, dwarfness and high productivity
Nutmeg	Epicotyl grafting, top working.	Female plants are propagated conservation of male plants to female plants. Rapid multiplication of elite plants per unit area.
Cinnamon	Cottage, air layering (rapid multiplication techniques).	Earliness,. More plants per unit area
Cassia	Air layering, cottage.	True to type plants
Allspice	Cuttage, layering.	Management of rhizome rot
Ginger and turmeric	Rhizomes	Crop rotation, solarization and disease – free rhizomes.

(Source: Spice Board, Cochin)

Some of the salient achievements of biotechnology in spices include micro-propagation and clonal multiplication in cardamom, black pepper, ginger, turmeric, cinnamon and vanilla. *In vitro* selection for resistance to biotic and abiotic stresses especially rhizome-rot in ginger is in progress. Protocols are also available for direct regeneration through tissue culture in long pepper, chaba pepper, kaempferia, curry leaf, tamarind, coriander, fennel, cumin, dill, lavender, aniseed, thyme and large cardamom. Synseed technologies are also available for cardamom, ginger, turmeric and pepper.

Spice Pests/diseases Bio-control agent tried

Black pepper *Phytophthora capsici, Trichoderma* sp. in combination with

scale insects, top VAM. Natural enemies viz., *Encarsia*

shoot borer, lounsburyi, Apanteles cypris, an import-nematodes ant parasite,

Verticilliumchlamydospor- ium, *Trichoderma* sp., VAM

Pollu beetle An entomophagous mite and

nematode

Cardamom	Rhizome-rot and damping-off	*Trichoderma* sp. and *Paecilomyces lilacinus*
Root-knot nemadote		*Paecilomyces lilacines*
Ginger and turmeric	Rhizome-rot	T harzianum, T hamatum, *T.uiride*
Coriander	Wilt	*T viride, T harzianum, Pseudomonas fluoresences*
Fenugreek	Root knot	*T uiride*

Environmentally friendly spices culture

The use of plant protection chemicals has led to residual toxicity in spice products. Moreover, there is a high premium for organic spices. Biocontrol of pests and diseases is another area where useful information is being generated.

A fungus, *Trichoderma* sp, in combination with VAM suppresses *Phytophthora capsici*, the causative organism of foot-rot in black pepper. Biopesticides to manage pests of spices are also being developed. There has been a major break-through in the generation of new technologies.

Spice Oils and Oleoresins

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.

Spice oils

In most spices, the odour or aroma factor is attributed to the volatiles (essentials oils) present in them. This 'essential oil' can be obtained by steam distillation of the ground spice. The oil is made up of hydrocarbons like terpenes, sesquiterpenes and their oxygenated derivatives.

Steam distillation is a gentle process, in which the oil components from the ground spices are entrained by steam at a temperature less than 100°C. With a rapid flow of steam,

large quantities of oil can be collected.

Production

The spice is ground before distillation, using a suitable mill. The crushed material is distilled as quickly as possible to avoid any loss of oil. The distillation of oil should be carried out using stainless steel instruments to avoid metallic and other contaminations which are undesirable in materials used for food flavouring. The ground spice is kept in a cage with a perforated bottom. From an external source, steam is let in through the bed of the material. As the steam passes, it carries with it the volatile components of the spice by entrainment. The mixture of steam and oil passess through a water-cooled condenser, gets condensed and the mixture of water and oil enters the oil-water separator situated at the other end of the condenser. Since most of the essential oils are lighter or heavier than water, they are separated out and the oil can be collected easily.

Precautions have to be taken regarding the rate of flow of steam, condensate temperature, rate of distillation, etc., to ensure the best results. The distillation time should be sufficient to ensure complete recovery of all the important constituents of the oil.

The oil collected from the separator is filtered and dried over anhydrous sodium sulphate. The oil is packed in brown glass or tinned metal containers. The containers are filled to the brim to exclude air, since oxygen can cause deterioration. The oils are then stored in a cool place.

Supercritical fluid extraction technology (SCFE):

The SCFE system is the modern technology of making oils and oleoresins through carbon-dioxide processing. This system provides a modern cost-effective technology for value addition in the processing of various agricultural commodities like spices. The CO_2 extraction of essential oils utilises liquid carbon dioxide at low temperature (0 to + 10°C) and high pressure (8 to 80 atm) as a selective solvent. Under these conditions, CO_2 liquifies to become a non-polar solvent which is odourless, tasteless, colourless, easily removed without residues and non-flammable. Selectivity is demonstrated by the extraction of the under-graded essential oil plus the lighter molecular weight fractions of the resin, imparting the character of an 'absolute' to the extract. The liquid and supercritical gaseous extraction of spices and other aromatic plants offers many interesting and novel products to the food product developer. This technology is preferred worldwide for commercial-scale extraction because it offers a:

Superior product

- Delicacy and freshness is close to natural

- High potency of active components
- Excellent blending characteristics
- Longer shelf life
- Free of biological contaminates

Super technology

- Simultaneous fractionation of extract
- Pollution-free process
- Provides solution to international concerns
- No residual solvent
- No residual pesticide

Yields

The volatile oil content of different spices varies widely. It may be as low as 0.1% and as high as 18%.

Quality evaluation:

Ideally, the quality of spice oils should be assessed organoleptically by experienced, well-trained panels. But this method is slow and impractical when quick evaluations are needed by industry.

Physico-chemical properties like density, solubility, refractive index and optical rotation are used to characterise essential oils, but they do not provide complete information on the quality. Thin-layer chromatography, gas liquid chromatography, infrared spectroscopy, mass spectrometry, etc., are modern methods used for the objective assessment of quality of essential oils.

Spice oleoresins:

The oleoresins represent the total flavouring components of spices in a very concentrated form. They are very close to the flavour of the whole ground spice. Spice oils only give the aroma of the spice, whereas spice oleoresins represent the total flavour of the spice. Oleoresins are prepared by extracting the ground spice with solvents like alcohol, acetone, hexane, methylene chloride, ethylene dichloride and ethyl acetate. Care should be taken to use pure solvents (food grade) that do not leave behind high boiling residues, which affect the flavour adversely. The major advantages with oleoresins are: flavour stability, less storage space requirement and uniformity in flavour strength. The main steps involved in the oleoresin process are:

1. Grinding the spice
2. Extraction

3. Distillation of the miscella (extract)
4. Blending the finished product

The ground spice is placed in extractors, which are preferably made of stainless steel. The bed of material rests on a perforated false bottom. The solvent is let in at the top. It percolates down the bed of material, carrying with it the solubles like volatile oil, fatty oils, colours, resins and pungent principles. The contact time between the solvent and the spice particles should be sufficient to ensure diffusion and extraction of the flavour constituents. About 4 to 5 volumes of the solvent are required to get most of the solubles out of the ground spice. This volume can be reduced by using countercurrent extraction, where dilute extracts can be used for extracting fresh material.

The concentrated extract (miscella) is distilled to remove the solvent. A vacuum is used towards the end, to prevent damage by heat and to ensure the complete removal of the solvent. Since food laws require the oleoresin to contain not more than 30 to 60 ppm of solvent residue, the final traces of solvent have to the removed carefully.

For obtaining a standard quality oleoresin, it is important that the choice of the solvent, particle size of the spice and the ratio of solvent to spice are properly determined. Attempts have been made to prepare oleoresin by using the super-critical extraction technique. The process is yet to be commercialised.

The finished product (oleoresin) is a dark viscous liquid. The flavour or colour strength of the oleoresin can be adjusted to the required standard by dilution with permitted dilutents. It can be fortified with separately distilled essential oils to achieve a balance between pungency and aroma. The yield of oleoresin and the main constituent present in them, from some spices, are given in Table 13

Table 11 - *Yield of oleoresin and the principal constituent*

Spice	**Yield of oleoresin (%)**	**Principal constituent in oleoresin**
Pepper	10-12	Piperine (35-60%)
Ginger	4-7	Gingerene (25-30%)
Chillies	12-16	Capsaicin (2-4%)
Turmeric	6-9	Curcumin (20-30%)
Coriander	18-20	D-linalool (1.5-2.0%)

(Source: Spices Board, Cochin)

As mentioned earlier, the oleoresins are too viscous and concentrated to be used as such in flavour blends or food products. It is customary to disperse them on solid or liquid media to dilute them and make their use more easy.

Standards for spice oleoresins have been given by the Essential Oil Association of America. Other organisations like the Indian Standards Organisation and the International Standards Organisation have also prescribed such standards.

Applications of spice oils and oleoresins:

Spice oils and oleoresins can be used to advantage wherever spices are used, except in those applications where the appearance of the filler aspect of the spice is of importance. In addition to the benefits of standardisation, consistency, and hygiene afforded by spice oils and oleoresins, there is a huge potential in their use for new product development. New flavours and fragrances are constantly being sought to entice the consumer. This applies equally to food products, medications, as well as other non-food products.

Food:

Processed meats:

The use of spices, particularly pepper, in the manufacture of meat products, is traditional for imparting flavour and maintaining the quality of the products. The typical seasoning mix for fresh sausages, for example, consists of pepper, capsicum, ginger, nutmeg, plus herbs. For dry sausages and pickled meats, cardamom and coriander are also used.

The move to use oleoresins has been accelerated by the increasing size of manufacturing plants, where the use of spice extracts benefits production quality, as well as easy handling and cost savings.

The above-mentioned spices are used in the dispersed form of their oleoresin, while cardamom and coriander are used in the form of their oils.

Fish and vegetables:

The seasoning mix for both fish and vegetables, and particularly pickled or brined products such as herrings, contain a wide range of spices and herbs. The use of oleoresins, particularly dispersed oleoresins on a soluble base, will provide a means of easier preparation, reduced handling and costs.

Soups, sauces, chutneys and dressings:

The increasing demand for convenience products available in the form of a dry mix for ready reconstitution, has caused a rapid move from conventional seasoning towards dispersed or encapsulated oleoresins and oils.

Oleoresins of celery, pepper. capsicum, etc., are used in conjunction with the oils of onion

and garlic. Coriander and ginger extracts are used in barbeque sauces. The use of the lesser known but highly useful spices. such as fenugreek, broaden the new product opportunities.

Cheeses and dairy products:

The use of spices in cheeses is established in Germany, including 'Quark'. Spice extracts are unlikely to be used in these products as spices provide the flavouring and visual impact.

However, spice oils and oleoresins have significance in processed cheeses and savoury spreads.

Baked foods:

The use of cardamom baked goods in Scandinavia and Germany is traditional. The baking industry generally uses ginger, cinnamon and nutmeg. The move from the spice to their oleoresin has been effectively taking place for many years for ease of handling and simplicity in manufacture. The use of spice extracts in cake fillings, biscuits, and snack products is also steadily increasing.

Confectionery:

The use of spices and spice extracts in the confectionery area is rather rare, but the demonstration of the use of such material as cardamom oil and other extracts in toffees, chocolates, and others, has shown that they provide a very novel and pleasing confectionery ingredient which is new to the market.

Snacks:

Flavouring is an essential component of the appeal of snack products, and unusual because the flavour is often applied on the surface, either by spray coating or dusting. For this purpose, the seasoning mix has to be capable of being applied in spray form or powder. Oleoresins of pepper, chilli and celery, are widely used. Turmeric and chilli extracts are used to provide colour.

Beverages:

Spice oils are used for the preparation of soft beverages, for example, ginger oil in the preparation of ginger beer, etc. Some of the less well- known spice extracts can be used to produce very pleasing soft drink products. But, these are not yet widely known outside of the countries in which they originate

Cosmetics:

The use of spice oils in the preparation of creams, soaps. shampoos, lacquers, lipsticks, etc., is well known. However, some of the materials available from India are not yet widely used, nor are they recognised as providing a new dimension to cosmetic products.

The growing preference for herbal, spicy and spicy coniferous products like shampoos and hair tonics are noted, yet such extracts as those of cardamom and fenugreek are little heard of. The use of lesser known spice extracts can provide new product appeal.

Perfumes:

The perfumery industry uses a wide range of essential oils and oleoresins from sources far and wide, yet some of the lesser known oils and oleoresins are hardly used. An examination of the wide range of those available from India could well provide a new basis for products of appeal.

Hygiene products:

Products like toothpastes, mouthwashes, etc., depend on essential oils to provide their pleasing flavour, making them not only acceptable, but pleasant to use.

In cleansing materials, detergents, etc., spice oils provide the aromatic appeal in otherwise uninteresting sometimes offensive notes associated with some of the base products.

Aerosols:

The use of aerosols worldwide is increasing at a significant rate in products such as air freshners, polishes, lacquers, and many cleansing agents, and waxes, etc. All of these are perfumed with essential oils for pleasant and fresh aroma.

Pharmaceuticals:

Both oils and oleoresins are widely used in pharmaceutical products, to provide either a pleasant taste or aroma to render them pleasing and easy to use, which would otherwise be difficult to accept. These include medications, skin creams, cold remedies, etc.

Most staple foods are bland, although they provide important sources of nutrition and are essential for growth and maintenance. Food is made palatable and enjoyable by using spices and herbs which are valued for their flavour and colour. The use of whole spices in food processing is limited to the extent of providing 'eye appeal' to the final product and not imparting full characteristic flavours. The flavour moiety is well protected from evaporators and in whole spices by the cells. Whole spices release flavour slowly; ground spices release the flavour more quickly.

Need for value-added products

- Ground spices have a limited shelf-life and the flavour loss/ modification is considerable during grinding/storage. They are of poor hygienic quality and hence find restricted use in processed foods.
- Dispersed spices are prepared by blending spice oils and oleoresins with carriers like dextrose, salt, rusk, etc. They tend to lose flavour during storage due to the large

internal surface area on which the aromatic components are spread.

- The characteristic flavour (fresh)/aroma is absent in dried/ dehydrated spices like ginger, green chilli, garlic, curry leaf, etc.
- Spice oils do possess good flavour but are often incomplete and unbalanced. Some flavour components are readily oxidised. They are quite concentrated and hence difficult to disperse in product mixes.
- Spice oleoresins represent the total flavour profile of the spice being concentrated (10-50 times the spice). They are viscous and difficult to incorporate in to the end product. Solvent residues (high boiling fractions) contribute to off-odours and off-flavours. Doubts have also been raised regarding the safety-in-use of residual organic solvents in spice extractives.
- Processing steps like ultra-high temperature and microwave demand stable flavours.
- The growing demand for convenience foods needs suitable stable flavouring materials.
- Better flavour quality can be obtained by suitable blending of naturals and synthetics.

Irradiated spices

Whole or ground spices are unhygienic since they are contaminated with a heavy load of saprophytic and thermophilic bacterial spores, moulds and yeasts (10^2-10^7/g). Gamma irradiation serves as an effective means of reducing bacterial load in natural spices. A dose of 3 to 10 KGY can reduce the viable cell count to an acceptable level of $<10^4$/g and the flavour quality remains unaffected.

Liquid water-soluble emulsion

The oil or oleoresin can be extracted in glycerol. isopropanol, propylene glycol, etc. Although the extraction is poor, the shelf-life of the emulsion is generally better. Solubilised spices are prepared by mixing them with a polysorbate ester (Tween 80) or by emulsifying them with plant gums.

Encapsulated flavours

One way by which the loss of volatiles can be obviated is to encapsulate the flavouring components by using an impermeable shell, which locks in the aromatics and thereby considerably increases their shelf-life. Encapsulation is essentially a method of providing a 'wall' material around the 'core' flavour, thus protecting the flavour from deterioration/oxidation. In this technique liquid droplets/particles are trapped in a continuous film of a polymer-celled wall material. The selection of the wall material is governed by its final end use. There are several methods of encapsulation like spray drying, molten extrusion,

molecular inclusion, gelatin coating, spray cooling, etc. Encapsulated flavours are particularly useful in dry mixes and convenience foods.

Spray drying

This is the most widely used method for the encapsulation of flavours. The method involves two unit operations, viz., emulsification of the spice flavour with an aqueous solution of plant gum/modified starch and dehydration in a suitable drying chamber. The 'core' flavour is homogenised with gum/starch solution and the emulsion is pumped in controlled amounts to the spray dryer's centrifugal atomiser. The dried particles are carried away in the stream of air and separated in a cyclone collecting chamber. There are several processing parameters which decide the product quality. These are viscosity of the emulsion, flavour load, degree of homogenisation, in-feed temperature, in-feed flow rate, operating variables of the spray dryer, etc.

Molten extrusion

Otherwise known as Sunkist fixation method, this was originally employed for the encapsulation of citrus flavours. Extrusion as applied to flavour encapsulation means that a flavour emulsion is forced through a die. A mixture of glycerol and corn syrup solids is heated to a molten state and cooled to a semiplastic mass when the essential oil is added and emulsified. The hot emulsion is extruded into a cold solvent when the filaments or standards harden, These filaments are impact-broken, separated from the solvent, dried under vacuum conditions and suitably packed after the incorporation of an anti-caking agent.

Molecular encapsulation

The encapsulation occurs on a molecular basis with beta-cyclodextrin. The reaction between beta-cyclodextrin and a suitable guest molecule takes place in a solution. Unlike spray drying, molecular inclusion techniques have the disadvantage that some of the chemical constituents cannot be encapsulated. The use of beta-cyclodextrin is approved of by some countries like Japan, Hungary and the Netherlands.

Spray cooling

A variant of the spray-drying process is known as 'spray cooling'. The product is prepared by blending an essential oil/oleoresin with a fatty carrier (hydrogenated fat). It is formulated for use in products such as mayonnaise, bakery, etc. In the hydrogenated fat, the product may be in the form of a solid block, which must be melted before use or it may be spray coated to obtain a free-flowing powder. To obtain a spray-cooled spice, the blend of spice oil/oleoresin and the fatty carri,er is melted to 45-120°C and atomised in a stream of chilled inert gas (nitrogen) when minute fatty globules are formed and instantly 'set', thereby

protecting the entrapped flavour. An antioxidant may be added to delay the onset of rancidity on storage. The use is limited to fatty products such as dry cake mixes, potato chips, etc., since it is water insoluble. Other methods of encapsulation do not find use in food applications.

Organic Cultivation

In recent years, organic agriculture has been gaining considerable importance. Many farmers today show interest in organic cultivation. Several of them have begun switching to this traditional method of cultivation as a means to produce safe foodstuffs and preserve the environment. The concept of sustainable farming has finally caught on in India.

World demand for organic foods

The world demand for organically produced foods is growing rapidly in developed countries in Europe, in the USA, Japan and Australia. The current estimated share of organic foods in these countries is approximately 1 to 1.5 per cent which is expected to increase to 10 per cent in the next couple of pentinniums. The market size of organic spices in the US is 30,000 tonnes, Europe 21,000 and Japan 6,000.

The worldwide food trends are changing with a marked health orientation. Since organic foods are free from chemical contaminants, the demand for these products should steadily increase in the new millennium. According to the ITC, UNCTAD/GATT, more than a 130 countries produce certified organic foods. Many of them are from Asia and Africa. Internationally, there is a definite shift towards traditional/ethnic medicines. Since spices form part of many of these medicines, the demand for organically produced spices should grow.

Organic cultivation is nothing new to India. The country has always been practising the traditional ways of using indigenous technologies and inputs, mostly in line with modern organic farming principles. The per capita consumption of fertilisers and pesticides in India is far below that of the other developed countries. This means that it is very easy for Indian farmers to embrace organic spice farming in its true sense.

The Spices Board, India, has taken a major initiative in promoting the production and export of organic spices on a large scale.

The Indian initiative

The export of organic spices from India has started in right earnest. The country at present exports around 50 tonnes of different varieties of organic spices. These exports will get a significant boost in the coming years as more farmers are switching to organic methods.

The Spices Board, India, has prepared a document on the production of organic species. It

features the organic concepts, principles, basic standards, production guidelines, documentation, inspection and certification. The document has been published after approval by the National Standards Committee constituted by the members of IFOAM in India.

Research programmes on the organic cultivation of important spices have commenced. The work is being carried out at the Spices Board's Indian Cardamom Research Institute at Idukki District in Kerala. Besides organising demonstrations to educate and motivate prospective organic spice growers, the Board is simultaneously involved in conducting training programmes for existing spice growers, on organic principles and practices.

Developing organic spices

The Spices Board encourages non-governmental organisations and farmers' groups to promote and adopt organic farming techniques. Infrastructure development for production of organic input is underway in prominent growing areas. The development of vermi-compost units and the supply of post-harvest aids for upgrading the quality of the produce at the farm level are also in progress.

Certification of organic spices

Certification for organic spice farms is an essential pre-requisite for marketing their produce, especially in the international markets. The Government of India is in the process of setting up indigenous certification programmes, since there is no domestic certifying agency in India. However, the offices of certain international certification agencies do operate in India.

For timely inspection at optimum cost, the Board has access to the services of trained inspectors from both governmental and nongovernmental organisations. These inspectors were trained in 1998 by the members of IFOAM in India. They will commence work once the domestic certification body is set up and approved by the competent authorities.

Help in sourcing organic spices

The Spices Board provides assistance to overseas buyers in sourcing organic spices from India. The country has the capability to produce and supply a variety or organic spices. If firm orders are placed well in advance, farmers can go ahead with confidence, cultivate squeaky- clean spices organically, and deliver them on time.

What follows is a list of agencies/farmers involved in the production and export of organic spices/spice products from India. The products covered are black pepper, white pepper, cardamom, clove, nutmeg, mace, ginger, turmeric, vanilla and seed spices. Many of these farms are certified, while others are either in the process of getting certification, or have initiated the necessary action.

Classification of Spices

Indian spices can be classified in different ways depending on the plantparts used, the economic importance, climatic requirements, origin and flavour, requirement of season and botanical description. But none of the classification is complete as each classification has got some lacuna or overlappings.

1. 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, curryleaf, bayleaf, chive, rosemary and savory

f) **Rhizome:** Turmeric, ginger, and galangal

g) **Pod:** Vanilla and tamarind

h) **Kernel:** Nutmeg

i) Floral part: Saffron, savory, caper and marjoram

j) Bud: Clove and caper

k) Latex: Asfotida

I) Aril: Mace and anardana

m) Berry: Black pepper, juniper and allspice

2. 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.

1. 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.

2. 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:

1. **Seed spices:** Coriander, cumin, black cumin, fennel, aniseed, celery, mustard, poppy and caraway.
2. **Bulbous spices:** Garlic, onion, leek and shallot
3. Aromatic spices: Clove, cinnamon, allspice, aniseed and nutmeg
4. Leafy **spices:** curryleaf, mint, rosemary, bayleaf, and parsley.

v) Acidulant tree spices: Tamarind, kokam and anardana

3. 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.

i) **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.

ii) **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.

iii) **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.

4. Based on origin and flavour

Depending on the origin and flavour content of the spices, they can be classified as follows:

i) **Aromatic spices:** Cardamon, aniseed, clery, cumin, coriander, fenugreek and cinnamon.

ii) **Pungent spices:** Ginger, chilli, black pepper and mustard

iii) **Phenolic spices:** Clove and allspice

iv) **Coloured spices:** Turmeric, saffron and paprika

5. Based on season of growth

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

i) **Annual spices:** Spices which complete their life cycle in one growing season are called annuals. Example of this type of spices are coriander, cumin, fennel, fenugreek, ajowan and

black cumin.

ii) **Biennial spices**: It needs two growing seasons to complete the life cycle. Examples of biennial spices are onion and parsley.

iii) **Perennial spices**: Perennial spices are those which live for more than two years. Black pepper, saffron, -clove, nutmeg and cinnamon are example of perennial spices

6. Based on botanical description

Table 12: botanical description of some spices

Name	**Botanical name**	**Family**	**Habit of**	**Parts**
Onion	*All/urn cepa*	Alliaceae	Annual	Green
Garlic	*All/urn sativum*	Alliaceae	Annual	Green
Cumin	*Cuminum cyminum*	Apiaceae	Annual	Fruit
Coriander	*Coriandrum **sativum***	Apiaceae	Annual	Leaf and
Aniseed	*Pimpinella an/sum*	Apiaceae	Annual	Fruit
Black cumin	*Nigella sativa*	Apiaceae	Annual	Fruit
Fennel	*Foeniculum **vulgare***	Apiaceae	Annual	Fruit
Mustard	*Brass/ca juncea, B. nigra*	Brassicaceae	Herb, Annual	Seed
Chilli	*Capsicum annum*	Solanaceae	Annual	Fruit
Cinnamon	*Cinna*momum *verum*	Lauraceae	Perennial Tree	Leaf a
Clove	*Euginia caryophy/lus*	Myrtaceae	Tree	Flower
Black pepper	*Piper nigrum*	Piparaceae	Perennial	Fruit
Cardamom	*Elettaria cardamomm*	Zingiberaeeae	Perennial	Fruit
Cardamom	*Amomum subulatum*	Zingiberaeeae	Perennial	Fruit
Turmeric	*Curcuma longa*	Zingiberaeeae	Perennial	Rhizome
Ginger	*Zingiber officinale*	Zingiberaeeae	Perennial	Rhizome
Curry leaf	*Murraya koenigi*	Rutaceae	Shrub	leaf .

Table 12.1: Types of spices based on the useful part.

Wholefruit (Berries)	Juniper berry,allspice, black pepper, chilli, Zanthoxylum (Japanese pepper), seed spices like cumin, fennel,

Bark	Cinnamon, cassia
Aril	Mace of nutmeg
Buds	Clove
Bulbs	Garlic, onion
Pistil	Saffron
Kernel / seed)	Nutmeg
Leaves	Basil, bay leaf, marjoram, sage, curry leaf, rosemary, etc.
Rhizome	Ginger, turmeric, mango ginger, Aplinia, etc.
Exudate	Asafoetida
Root	Angelica, horse radish
Seeds/fruits	Aniseed, caraway,coriander, dill,fenugreek, mustard etc
Fruit pulp/rind	Tamarind and Garcinia

Table 12.2: Spice based on morphology of aerial parts.

Herbs	Ajowan, coriander. Cumin, tenet, fenugreek, chillies, parsley
Shrubs	Rosemary, Chillies (perennial chillies), Pomegranate
Trees	Nutmeg, clove, cinnamon, tamarind, Garcinia, Japanese pepper
Climbers	Black peopper, tailed pepper, vanilla
Perennialherbs (rhizomatous herbs)	Ginger, turmeric, mango ginger, Japanese ginger, galanga, asafetida.

Table 13: Present a mixed combination of above classification is normally followed since none of the classification is complete as each classification has got some lacuna or over lappings, which is mentioned as below.

Mixed combination classification of spices.

Major spices	Black pepper, Chilli, ginger, turmeric, cardamom,
Major seed spices	Coriander, cumin, fennel, fenugreek

Minor seed spices	Ajowan, celery, parsley, dill caraway, black cumin, black caraway.
Major tree spices	Nutmeg, clove, cinnamon, tamarind, allspice, kokum, curry leaf.
Herbal spices (Herbs)	rosemary, thyne, parsley, etc.
Others (Miscellaneous)	Saffron, asafoetida, vanilla, garlic etc.

Value Added Spice Products

Value added products indicates that for the same volume of a primary product, a high price is realized by means of processing, packaging and upgrading the quality or other such be handled per unit area, also encourages the growth of ancillary industry and fetches increased foreign exchange. Majority of total spices trade (about 85%) is in the raw and bulk form. Thus there is a vast scope for exporting the processed and value added spice products in India. The value added spice products have certain advantages that are mentioned below:

1. It imparts their total flavour and keep intact the aromatic constituents.
2. It does not varies in flavour, strength and quality.
3. It is more hygienic than whole spice.
4. It fetches increased foreign exchange.
5. More volume can be handled per unit area.

6 It helps to encourage the growth of ancillary industries. 7. It is easy to store.

Therefore, emphasis should be given on the production of more value added spice products as there is a vast scope to export the processed and value added spices. The following are the different kinds of value added products in spices.

1. Spice oil

Spice oil is obtained by steam distillation of various parts of the spices. The essential oil thus obtained are endowed with the major part of the flavour and fragrance properties of the spices. Following are the various types of spice oils:

(a) Pepper oil: Oil is obtained by steam distillation of dried and crushed berries of black pepper. This oil is used for flavouring of food especially when anyone wants the pepper like aroma without pungency. The oil content varies from 2-4%.

(b) Ginger oil: Ginger oil is obtained from the ground dried ginger rhizomes by distillation. Usual yield of oil is 1.5-2.5%. But higher yield of about 4% has also been observed. Ginger

oil contains sesquiterpene, high carbon compound like gingiberine and some oxygenated carbons also. Ginger is valued for its pungency, heat and flavour. The major pungent principle is due to the presence of gingerole.

(c) **Cardamom** oil: Cardamom oil is present in the seed and whole fruit *i.e.* the capsule. The ground powder of it is used to impart the aroma in the foods. To obtain the oil, the seeds are steam distilled. It yields oil of 6-8% in capsule and 8-12% in seed. The major constituents of cardamom oil are cineole and terpenyl acetate.

(d) **Nutmeg oil:** It has 2-15% oil. Bulk of which is composed of terpene hydrocarbons. The oxygenated derivatives consists of geraniole, linalool, terpinole, safrole and elemicin.

2. Oleoresin

Oleoresin is the concentrated product which is obtained by extraction of the dry spices. The extraction is done by using an organic solvent or solvent 'mixture like ethylene$_{ik}$chloride, acetone, alcohol and hexane. Oleoresin represents the complete flavour of the concentrated fresh spice. It contains volatile as well as non-volatile constituent of the spice. The residual solvent in the oleoresin should be below 30 ppm. Oleoresin can not be used directly because it is too concentrated and is diffeti^{c}to dispense. But oleoresin can be used directly in the fatty products like processed meat, fish cheese, baked food and vegetables. Oleoresin has greater heat stability than essential oils.

3. Curry powder

It is the powdered blend of a number of spices. It has a good export potential. The number of spices vary from 5 to 20 depending on its end use. Different spices like turmeric, coriander, cumin, fennel, fenugreek, black pepper, chilli, *etc.* are used to prepare quality curry powder. The composition of curry powder changes according to different needs. The colour, form and taste of it varies in accordance to the custom of various nations and regions. Spices are ground and then mixed in a definite proportion to prepare curry powder. It generally contains 85% of spices, 10% farina and 5% salt. A wide range of products are generally covered under this category. This includes mixed power, straight powder, curry powder, curry mixture, masalas and curry paste. It is used to impart a distinct flavour to a variety of preparation like chicken, fish, meat, vegetable noodles and tea.

4. Ground spices

The spices which are milled to the degree of fineness like coarse grind, finegrind and cracked, *etc.* called the ground spices. There a considerable amount of heat is evolved during grinding operation] which results in loss of flavour. To over come this problem, spices are now milled at a low temperature.

5. Consumer packed spices

The spices which are exported to the developed foreign countries are consumed in three main segments *i.e.* industrial, institutional and retail. Various types of packaging media are used according to the consumer's preference or choice. Different types of packaging media like plastic films, aluminium foils, laminations, flexible pouches are used. By exporting consumer packed spices, higher unit value for the same quantity can be earned.

6. Organic spices

The awareness and growing concern of health and hazards through chemical residual toxicity led to the development of organic crops and organic spices also. The demand for organic spices is increasing. The organic agriculture has got tremendous importance in the international market. India has become a member of the countries exporting organic spices. Major consumer countries are USA, Europe and Japan. Organic products are more expensive than the conventional ones.

REFERENCES:

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
5. Extension pamphlet, Black Pepper, 2009, *Spice Board*, Cochin PP 3-24.
6. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
7. Farooqui, A.A. and Sreeramulu, B.S. 2001, cultivation of Thyme – a herb spice, *Spice India* 13 (2):19-21.
8. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
9. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
10. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
11. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
12. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
13. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micropropagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.

14. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
15. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
16. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.
17. Pruthi, J.S., 1989, Major Spices of India, Crop management Post-Harvest Technology, published by *Indian Council of Agricultural Research*, New Delhi.

OBJECTIVE TYPE QUESTIONS & ANSWERS

Questions:

I. Choose the correct answers in the following:

1. How many spices grown in India.

a) 60 b) 63 c) 62 d) 65

2. Which is the chemical present in cloves that inhibits the growth of bacteria

a) Ethanol b) Methanol c) Eugenol d) None of these

3. Share of spices in the world trade is

a) 2-5 % b) 5-15 % c) 20-25 % d) 15-20 %

4. Leading state in black pepper production in India

a) Kerala b) Karnataka c) Maharastra d) None of these

5. In India the area under turmeric during 2009-10 was

a) 1.50 lakh hectares b) 1.90 lakh ha. c) 1.80 lakh ha. d) 1.20 lakh ha.

6. Spices that are irradiated, reheated with ethylene oxide are prohibited under

a) ISD guidelines b) ASIA specification c) Japanese Sanitation law d) All these

7. To avoid mould infestation and rancidity some spices need to be stored at low temperature of about

a) $0.5^{o}C$ b) $2\text{-}5^{o}C$ c)$1\text{-}5^{o}C$ d) $0.5^{o}C$

8. Which country is the major competitor for Indian black pepper

a) Vietnam b) China c) Bangladesh d) Japan

9. Indian Cardamom Research Institute started in the year

a) 1976 b) 1974 c) 1978 d) 1972

10. Method of propagation followed in clove is

a) Trench method b) Inarching on seedling c) Grafting d) Rhizomes

11. The volatile oil content of different spices varies from

a) 0.1 to 0.5 % b) 1 to 8 % c) 0.1 to 18 *%* d) 0.1 to 10 %

II. Write whether the following statement is true or false:

1. Species and condiments are high volume and low value crops**.**
2. Indian spice export showing increasing trend of export earnings in recent years**.**
3. Ground spices tend to have better shelflife than whole spices**.**
4. Internal price of black pepper is dependent on foreign demand**.**
5. In Kerala spices are marketed through regulated markets**.**
6. The CPCRI was upgraded and designated as National Research Centre for spices in 1986**.**
7. Phytophthora foot rot disease found in Ginger**.**
8. Encapsulation is a method used to prevent moulds in spices**.**
9. India at present exports around 100 tonnes of different varieties of organic spices**.**
10. Chilli is considered as major seed spice**.**

III. Match the following:

Part - A		**Part - B**	
1	Garcinia	A	Reducing bacterial load in spices
2	Grinding and sterilizing	B	Temperate spice
3	Cardamom	C	Extraction of the dry spice
4	Turmeric	D	Enginia Caryophylus
5	Gamma irradiation	E	Pungent spice
6	Saffron	F	Sugandham
7	Mustard	G	Anti obesity
8	Clove	H	Katte disease
9	Ginger	I	Brassica juncea
10	Oleoresin	J	Decrease the volatile oils in spices

Answers:

I main		II main		III main	
Sl No	Answers	Sl No	Answers	Sl No	Answesr
1	**a**	1	**F**	1	**G**
2	**c**	2	**T**	2	**J**
3	**c**	3	**F**	3	**H**
4	**a**	4	**T**	4	**F**
5	**c**	5	**F**	5	**A**
6	**c**	6	**T**	6	**B**
7	**b**	7	**F**	7	**I**
8	**a**	8	**F**	8	**D**
9	**a**	9	**F**	9	**E**
10	**b**	10	**F**	10	**C**
11	**c**				

LECTURE 4 & 5

BLACK PEPPER

Scientific Name : *Piper nigrum*
Family : *Piperaceae*
English name : Black Pepper
Indian name: *Kali Mirch* (Hindi), *Kare Menasu* (Kannada), *Kurumaluku, Nallamulaku M*alayalam), *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.

Scope and Importance:

The black pepper is originated in tropical forests of Western Ghats in India, the hilly reason and costal climate of the country are more favourable for cultivation of pepper. Similarly the prevailing soil types, red sandiloam, lateritric soils and forests soil rich in humus are ideal for cultivation of this crop. Pepper is shade loving crop and suitable for cultivation as inter/mixed/multistoried cropping system in arecanut, coconut, coffee, tea, cardamom and cashew plantations. The large area available in these crops has good scope for expansion of area under this crop. It is considered to be good remunerative crop in these plantations. Among the spices the black pepper contribute maximum for an exchange to the Indian economy. Pepper and it's products are great export demand. Pepper is used has whole and powder form as spice in culinary preparations, peppering essential oil and oleoresins extracted from pepper has got great demand in pharmaceutical and cosmetic preparations. The value added products of pepper has great demand in food processing industries. Considering the demand, importance and favourable agro-climatic conditions of the country have good scope for expansion of area and to enhance the productivity of the crop by utilizing the high yielding varieties and scientific practices available.

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.
   Leaves: Alternate, simple, lamina leathery, ovate, round or obtuse.

The spike is a catkin type of inflorescence, which emerges opposite the upper leaves, on the plagiotropic branches. It is 3-15 cm long with 50-150 minute white to pale yellow flowers. The flowers are either unisexual with monoecious or dioecious forms, or bisexual, as seen in many cultivars. Under intense shade conditions, the hermaphrodite type produces more female flowers and less bisexual flowers. The flowers are cross-pollinated and thus much variation occurs among the progeny. Moreover, hermaphrodite flowers are protogynous; i.e., they attain receptivity well in advance of the pollen maturity, which results in uneven fertilisation of flowers and non uniform, incomplete filling of the spikes.

Flowering begins at the base of the spike and continues to the tip over a week. It is found that bagged inflorescence produces fruits, indicating that the hermaphrodite cultivars (Eg: Balankotta, Kalluvalli) are self-fertile and self-pollination can occur without the aid of rain or wind. The pollen is in glutinous masses of several grains, which is broken up by light showers and the grains are trapped in the papillae of the stigma. But wind pollination has not been found to be very efficient. It seems that pollination is confined mainly to individual spikes. The fruit is a one-seeded green berry, sessile usually globose and sometimes elongated or oval. The seed is surrounded by a thin, soft pericap. During ripening, it becomes yellow and turns light red afterwards. The period taken from flowering to maturity is about 6 months.

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.

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. The leaves are medium, ovate, elliptic and the spikes are medium and are the twisting type due to very thick setting. The berries are small to medium, heavy and have high driage (about 40%). It is a regular bearer and reportedly tolerant to water stress and diseases. Studies have shown that it is moderately tolerant to *Ph* ytophthora wilt. Though it is a very promising cultivar, its distribution is rather restricted to settlement areas of the submontane pepper tracts of Wynad and Cannanore districts.

The Kalluvally found in many areas in Cannanore and north Wynad does not conform to the above description. More than one cultivar is known by this name and some of these are rather poor yielders. They do not seem to be as hardy as the name indicates. The Kalluvally types are also found to differ in quality factors. For example, three Kalluvally types gave the following values; oleoresin (%) 8.8, 10.9 and 8.4; piperine (%) 4.2, 4.6 and 5.4, essential oil (%) 3.4, 0.4 and 3.0 and starch (%) 31.5, 29.0 and 20.7.

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 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. It is an average and regular bearer and has 30% driage. It gives 9% oleoresin, 3.9% piperine and 3.7% essential oil.

Valiakaniakkadan has slightly larger leaves, longer spikes, and bold and heavy berries, and its berry setting is good. It is a moderately high yielding type.

The other two Kaniyakkadans are also moderate yielders.

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. Its oil content is high and so has a very high flavour quality.

Balancotta is reportedly tolerant to moisture stress and is also somewhat tolerant to *Phytophthora* wilt. In the Malanad areas of North Kanara, this cultivar is grown under the name Malabar Pepper, especially in Sagar, Koppa, Sirsi and adjoining areas.

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.

Kartmunda

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. This had been the traditional cultivar of central Kerala comprising Palai, Ponkunnam and the adjoining areas. 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. In central Kerala, most of the vines have short, well-filled spikes, but the spikes found in the Idukki district and also in parts of Wynad are much longer. 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. The ovate leaves are medium-large, the spikes are very long and slender (like a horse's tail, hence the name Kuthiravally) 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. The leaves are small to medium, ovate and have a characteristic twisting that results from a thick berry setting. The persistent stigmatic base looks like a 'pin' and hence the name `Narayakkodi' (Narayam is a long iron-nail like tool used in the olden days for writing on palm leaves). 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 `Karimunda[l] 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).

Table 7. High yielding varieties of black pepper and their characteristics

Variety / Year of release	Pedigreel Parentage	Institution! University	Av. yield kglha (dry)	Salient features
Panniyur 1 1971	Inter-cultivar hybrid of x Cheriyakaniyakadan	Pepper Research Station (KAU), Panniyur, K arirnbam 670 143, K	1242 (Pot! yield 8800)	Vigorous growing vine. Donot tolerate shade. Long spikes, clo se setting o f berries, bold b errie s, oleoresin !1.8%,piperine 5.3%, essential oil 3.5%, dry recovery 35.3%
Panniyur 2 1991	Clonal selection from op en pollinated progeny ofB alankotta	-do-	2570 (Pot! yield 3313)	Shade tolerant, suitable for intercropping, medium maturity group, medium quality, oleoresin 10.9%, high piperine (6.6%), essential oil 34%, dry recovery 35.7%
Panniyur 3 1991	lnter-cultivar hybrid of x Cheriyankaniyakadan	·do·	1953 (Pot!. yield	Suitable for all pepper growing regions, performs well under open situation. Late maturity group. Long spikes and bold berries, piperine 5.2%, oleoresin 12.7%, essential oil 3.1%, dry recovery 27.8%
Panniyur 4 1991	Clonal sel ection from Kuthiravally type II	-do-	1277 (Pot!. yield	Stable yielder, performs well under adverse condition also, tolerant to shade, later maturity, 44% piperine, 9.2% oleoresin, 2.1% essential oil and 34.7% dry recovery
Panniyur 5 1996	Clonal selection from op en pollinated progeny ofPerumkodi	-do·	1110 (Pot!. yield	Suitable for bo th m ono and mixed croppin g in coconut / arecanut gardens, shade tolerant, medium maturity, tolerant to nursery disease. Long spikes, piperine 5.3%, oleoresin 12.33%, 'essential oil 3.8% and dry recovery 35.7%
Panniyur 6 2000	Clonal selection from Karirnunda typ e III	-do-	2127 (Pot! yield 3359	A vigorou s vine. Tolerant to drought and adver se climatic conditions, stable and regular bearer, medium maturity group. Suitable for open condition as well as partial shade, spike 6·8 cm, more number of spikes/unit area, close setting and attractive bold berries, piperine 4.9%, oleoresin 8.27% and essential oil 1.33% and 33.0% dry recovery
Panniyur7 2000	Open pollinated progeny of K alluvslly	-do-	1410 (Pot! yield 2770)	Vigorous vine and a regular bearer, long spike, a hardy type vine, tolerates adverse climatic condition, suitable for open and shaded conditions, very long spike (16·24 cm) high pip erine content (5. 6%), oleoresin 10.6%, essential oil 1. 5% and 34.0% dry recovery

Sreekara 1990	Clonal sel ecti on from Karirnunda	Indian Institute of Spices Research, ICAR., Calicut - 673 012 Kerala	2677 (PotL yield, 4200)	Suitable for all pepper growing regions including high elevations as well as for intercropping, medium maturity, gives quality pepper with 5.1% piperine, 130% oleoresin, 7.0% essential oil and 35.0% recovery	Kerala, South Kamataka and Tarnil nadu
Subhakara 1990	Clonal sel ecti on from Karimunda	-do-	2352 (PotL yield 4487)	Wide adaptability to all pepper growing tracts. Suitable [or intercropping as well [or high elevations, high quality, medium maturity, piperine 3.4%, oleoresin 6.0% essential oil and 35.0% dry	Kerala, South Kamataka and Tarnil nadu
Panchami 2001	Clonal sel ecti on from Aimpiriyan	-do-	2828(Potl. yield 6528)	High yi elding, spikes twisting, late maturing, suitable for high elevations, excellent fruit set, piperine 4.7%, 12.5%,3.4% essential oil and 34.0%dry recovery.	Kerala Kamataka
Poumami 2001	Clonal selection from Ottaplackal	-do-	2333(Potl. yield 5326)	Tolerant to root knot nem atode and Medium maturity, suitable for intercropping with arecanut anfbanana. Piperine 4.1%, oleoresin 13.8%, essential oil 3.4% and dry recovery 31.0%	Kerala and Kamataka
IISR Thevam	Clonal sel ecti on from germplasm of Thevanmundi	-do-	2437(5.00 kg/vine fresh)	Stable yielding, grow vigorously, field tolerant to *phytopthora*, medium suitable for high altitude areas of South India up to 3000 ft MSL in coffee and tea estates. Piperine 1.6%, oleoresin 8.15%, essential oil 3.1 % and dry recovery	K eral a and altitude areas of South India up to 3000 ft MSL
IISR Malabar Excel	A hybrid of Cholarnundi x Panniyur - 1	-do-	1453 (3.00 kg/vine fresh)	Recomm ended for rain fed condition including coffee and teaplantaton. Oleoresin 11.7%,piperine 2.4%, essential oil 2.8%, dry recovery 32.3%. Suitable high elevations and plains	Kerala and high altitude of South India
IISR	A hybrid of Cholamundi x ,	-do-	2880 (6.00 kg/vine/	Recommended for rain fed conditions	Kerala and other

Girimunda	Panniyur -1			including tea and coffee esates. :maturity group. Piperine 2.2%, oleoresin 9.65%, es sential oil 3.4 % and dry rec 320%.	high altitude areas ofS. India
IISR-Sakthi (P-24)	Open pollinated seedling progeny o f cv. Perambra mun di a clonal cultivar	-do-	(5.2kg/vine, fresh) (PotL yield 5755)	'Tolerant to *P capstci*, piperine 3. 3%, oleoresin 10.2%, essential oil 3~7% and dri age 43.0%.	Kerala and Kamataka pl and hi gh ranges
PLD - 2 1996	Clonal sel ecti on from K ottan an dan	NRC [or Oil Palm, Regional Station, ICAR, Palode, Pacha (Post) - 695562, Kerala	2475 (Pot!. yield 4732)	Late maturity high quality cultivar, contains piperine 3.0%, oleoresin essential oil4.8%. Suitable for plains and bigher elevati ons.	Kerala

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 upto 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 45^{o} 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 litres 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 3^{rd} or 4^{th} 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 intermodal

stub 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/Cultivation
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 phorate*10 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 cm^3, 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 cm^3 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.

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 fertilisers 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.

The following is the nutrient dose for pepper (3 years and above): adopted in Karnataka.

	Per vine per year
FYM or Compost or green leaves	10 kg
N	100 g
P205	40 g
K2O	140 g

In Kerala fertilizers dose recommended for panniyour – 1 is 140:55:270 g of NPK per vine.

A one-third dose should be applied for one year old plants and half dose for two year old plants. The fertilizers may be applied in two split doses, the first in May-June and the second in August-September.

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 1,000 kgs/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 (Nybe, 2001). 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 n:atters 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.

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.

REFERENCES:

1. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
2. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
3. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
4. Extension pamphlet, Black Pepper, 2009, *Spice Board*, Cochin PP 3-24.
5. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
6. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.

7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.

8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.

9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.

11. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micropropagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.

12. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.

13. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.

14. Pruthi, J.S., 1989, Major Spices of India, Crop management Post-Harvest Technology, published by *Indian Council of Agricultural Research*, New Delhi.

OBJECTIVE TYPE QUESTIONS AND ANSWERS

Questions:

I. choose the correct answer in the following:

1. *Piper nigrum* is the botanical name of

a) Black pepper b) Hot Pepper c) Sweet Pepper d) None of these

2. Black pepper belongs to the family

a) Solanaceae b) Papilonaceae c) Piperaceae d) None of these

3. Black pepper is also called as

a) King of spices b) Black gold c) Both a and b d) None of these

4. Origin of black pepper is

a) Mexico b) India c) Ethiopia d) Southern America

5. Major black pepper producing state of India is

a) Kerala b) Sikkim c) Rajasthan d) None of these

6. Growth habit of black pepper is

a) Small bushy plant b) Study erect plant

c) Climbing evergreen plant d) None of the above

7. One inflorescence of black pepper plant bears

a) 1-2 flowers b) 4-8 flowers c) 10-20 flowers d) More than 50 flowers

8. Indian Institute of Spice Research is located at

a) Tiruvanthapuram b) Calicut c) Jodhpur d) Bikaner

9. Foot rot disease in black pepper is caused by

a) Phytophthora b) *Pseudomonas* c) Virus d) *Xanthomonas*

10. Due to the oxidation of colourless phenolic compounds in pepper skin, its colour changes to

a) Orange b) Red c) Green d) Black

11. Essential oil content in black pepper ranges between

a) 0.025 to 0.05 % b) 2.5 to 3.5 % c) 8-10 % d) None of these

12. Oleoresin is extracted from

a) Small cardamom b) Large cardamom d) Black pepper d) All of these

13. The biting taste of black pepper is due to the presence of the alkaloid

a) Piperine b) Chovicine c) Peiperidine d) All of these

14. Pepper Research Station is located in Kerala at

a) Panniyur b) Kochi c) Kottayam d) Trivendrum

15. White pepper is developed from

a) Hot pepper b) Black pepper c) Both a and b d) None of these

II. State whether true / false

1. Black pepper starch contains minute polygonal granules resembling rice.
2. Kerala contributes to 95 % of the total black pepper production in India.
3. India is the largest exporter of black pepper in the world.
4. Black pepper flowers are protogynous.
5. Black pepper cannot be propagated by seeds.
6. Black pepper require 50 % or little less shade for good growth and production.
7. Spike shading is a major disorder in black pepper which results in considerable losses in yield**.**
8. Pepper is a perennial vine and bearing starts after third of planting.
9. Pepper is preferably grown in low rainfall areas.
10. Pepper varieties can yield upto 10 q/ha.

III. Match the following:

Part-A		Part-B	
1	Black pepper variety Narayakkodi	a	10-12 %
2	Essential oil in black pepper	b	Tolerant to food rot disease
3	Oleoresin content in black pepper	c	2.5 to 3.5 %
4	Kerala's share in India's total black pepper production	d	10-13 %
5	Optimum moisture content in white pepper	e	95 %

Answers:

I main		II main		III main	
Sl No	Answers	Sl No	Answers	Sl No	Answers
1	**a**	1	**T**	1	**b**
2	**c**	2	**T**	2	**c**
3	**c**	3	**T**	3	**d**
4	**b**	4	**T**	4	**e**
5	**a**	5	**F**	5	**a**
6	**c**	6	**T**		
7	**d**	7	**T**		
8	**b**	8	**T**		
9	**a**	9	**F**		
10	**d**	10	**T**		
11	**b**				
12	**d**				

13	**d**				
14	**a**				
15	**b**				

LECTURE 6 & 7

SMALL CARDAMOM

Scientific Name: *Elettaria cardamomum* Maton.

Family : *Zingiberaceae*
English name : Small cardamom, Lesser cardamom, Malabar cardamom.
Indian name :*Chhoti Elaichi*(Hindi), *Yelakki*(Kannada), *Elathari* (Malayalam), *Ela* (Sanskrit), *Yelakkai, Elakkai* (Tamil), *Yealakkayulu, Elakkayi* (Telugu)

The small cardamom, popularly known as 'Queen of Spices' is a tall perennial herbaceous plant in the family *Zingiberaceae*. Cardamom of commerce is the dried capsule of this shade loving plant indigenous to the evergreen forests of Western Ghats of South India.

Origin and distribution:

Cardamom is indigenous to the evergreen rainforests of Western Ghats of southern India from where it spread to some other tropical countries such as Sri lanka, Tanzania and a few Central American countries. Presently, it is being cultivated in not less than twelve countries from three continents lying between 20^{o} latitude north and south. Cardamom was an article of Greek trade during the 4^{th} century B.C. It was listed among the Indian spices liable to duty at Alexandria in A.D. 176. The cultivation of cardamom in India was actively taken up by the erstwhile Travancore Government in 1823 A.D.

The major cardamom-producing countries besides India are Guatemala, Sri Lanka, Thailand, Tanzania and Cambodia. Cardamom is also produced on a smaller scale in Laos, Vietnam, Costa Rica and El Salvador. In India the Cardamom is cultivated in Kerala, Karnataka and Tamilnadu. In Kerala the major cardamom growing area are Travancore, in the Idukky district, Wayanad and Kottayam region. In Karnataka Coorg, Chikmaglore, Hassan and Uttara Kannada district, Palany, Nilagiris and Kodai hills of Tamilnadu.

Area and production:

India has been the world's largest cardamom producer until 1979-80, when Guatemala came to the scene as a major rival. At present, Guatemala is the world leader in production. Cost of production in Guatemala is reported to be only half of that in India and India finds it difficult to compete with Guatemala in the international market.

In India, small cardamom cultivation is restricted to the Western Ghats region of

Kerala, Karnataka and Tamil Nadu. The Indian cardamom has higher oil content and aroma. Kerala occupies the first place, contributing to about 60% of the total area and Karnataka covers about **31%** of the area, followed by Tamil Nadu (**9%**), with a production of 58.5, 34 and **7.5%,** respectively during the year 2009-10.

The average annual production of cardamom is reported to be around 15,000 tonnes obtained from 90,200 hectares in **2009-10.** India still meets about 60-65% of the world's demand through the export of cardamom to about 50 countries. During 2010-11, 11.75 tonnes of cardamom was exported earning a foreign exchange of Rs.13,216 lakhs. The important countries importing cardamom from India are Kuwait, Qatar, Saudi Arabia, the erstwhile USSR and Japan.

Botany:

Cardamom is a tall growing, cross-pollinated, herbaceous perennial, with branched subterranean rhizomes. The real stem is the rhizome, which is subterranean in habit. Cardamom is a shallow-rooted plant. The leaves are 35 cm long and 1-10 cm wide, distichous, linear and lanceolate in shape, with short petioles. The inflorescence or the long panicles with racemose clusters arise from the underground rhizome. The flowers open in succession from the base to the top and develop into fruits. The calyx is cylindrical and persistent and the corolla tube is shortly exerted. The fruit is a trilocular capsule; the capsules are globose and rounded. The seeds are black when fully ripe in a capsule and embedded or covered with a white mucilagenous coat. There are 15-20 seeds in each capsule with a hard seed-coat.

Scope and Importance:

Cardamom is indigenous to Western Ghats in south India, the hilly region of the country in Kerala, Karnataka and Tamilnadu are having more favourable agro-climatic conditions for cultivation of cardamom. The heavy rainfall, higher elevation and low temperature are congenial for cultivation of cardamom. Similarly the prevailing soil types, red sandyloam and forests soil rich in humus are ideal for cultivation of this crop. Cardamom is shade loving crop and suitable for cultivation as inter/mixed cropping system in arecanut and coffee plantations. The lower valleys of coffee and tea plantations having suitable micro-climate which is more favourable for cultivation of this crop. Cardamom is a high valued crop and good income generating crop. There is a lot of export demand because of high quality and also maximum internal consumption need expansion of area and more production.

Cardamom is used as a spice and flavouring of various preparations of food, confectionary, beverages and liquors. It is also used in flavouring of curries, cakes, bread and other culinary preparations. Cardamom is used in three forms viz., whole, decorticated seeds and ground. It is used for the extraction of essential oil and oleoresin. In Arab countries the coffee is prepared using cardamom is popularly known as Gahwa' it is a prestigious drink for them. Cardamom is used in flavouring of soft drinks, payasa, ghee rice etc., Oils and oleoresins are used in flavoring of cordials and preparation of chewing gums, perfumery and

cosmetics. It is also used in flavouring of medicines. Cardamom is a good stimulator for heart and liver. Cardamom tea is used to prevent dysentery, scanty urination, exhaustion due to over work. Cardamom with honey is reported to improve eyesight, strengthen nervous system. Cardamom is an essential ingredient of digestive stimulants and is used in medicinal preparations for indigestion and flatulence. The new products of cardamom are cardamom cola, instant gahwa, chewing gum, biscuits, encapsulated cardamom oil etc.,

Climate

The crop thrives well in evergreen tropical forests at an altitude of 600 m to 1500 m. above MSL. Cardamom is found to grow well even in areas where the annual rainfall ranges from 150-400 cm, provided the rainfall is well distributed. The better distribution of rain rather than high annual rainfall is the most important factor for a good crop. It grows well in a temperature range of 10° to 35°C. Valleys and gentle slopes facing the North or North-eastern direction, protected from strong winds, form an ideal situation for cardamom plantation. Cardamom requires filtered light for better growth.

Soil

Well-drained soils rich in organic matter, forest loams rich in phosphorus and potassium and deep light-textured lateritic soils with a pH range of 4.6 to 6.5 and plenty of humus are good for the crop. It is mostly grown as a pure crop in the lower portion of undulating valleys.

Varieties

Based on the size of the fruit, two varieties viz, *Elettaria* cardamom Maton variety *major*, made up of the wild indigenous types and the variety *minor* Watt (Syn.var. miniscula Burkill) comprising of the cultivated types are recognized. Among the various cultivated types, three major races viz., "Mysore", "Malabar" and "Vazhukka" are most popular and can be identified on the basis of certain specific morphological characteristics.

Malabar or prostrate type

This is the most common race cultivated on the Travancore hills and the southern Western Ghats. The plants are of medium size and grow 2-3 m in height. The leaves are either pubescent on the dorsal side, or sometimes glabrous. The panicles are prostrate and the fruit is roundish. This type is suited to the 600-1000 m elevational zone. The plants are early, short span of flowering, more drought resistant. The Malabar cardamom is considered to be more tolerant to the attack of thrips. This variety is mostly suitable for lower elevations.

Mysore or erect type

The plants are robust and grow to 3 to 5 m in height. The leaves are laceolate or oblong, glabrous on both surfaces, large and dark green, petiole long. The panicles are erect, late bearing long flowering span, the capsules bold, and more productive. This variety is suited to high elevations (900-1,200 m MSL) and withstands exposure to wind.

Vazhukka or semi-erect type

This is a hybrid of the "Mysore" and "Malabar" types and consequently the plants exhibit various characteristics which are intermediate between the two types. They are also adaptable to a fairly wide range of environmental conditions. The plants are robust (3 to 5 m height) like the "Mysore" types and have deep green leaves, semi-erect panicles and bold capsules. Late long flowering span suitable for higher elevation.

Malabar Type

Vazhukka type

Mysore Type

Improved cardamom varieties released from different research stations/institutes for cultivations.

Variety! year of release	Pedigree / parmtage and plant type	Institution! University	Av. Yield kg/ha (dry)	Salient features
Mudigere 1 1984	Clonal selecti on from Malabar type	Regi onal Research Station, UAS Mudigere- 577 132, Chikmagal ur (Dist.) Kamataka	275 (potL yi eld 1000)	Erect and compact plant, short panicle, pal e green, oval capsules, suitable for high density planting, moderately thrips, hairy caterpillar and white grubs, pubescent 8.0% oil, 36.0% 1,8 cineol, 42.0% a:-terpenyl acetate, recovery 20.0%
Mudigere 2 1996	Clonal selection from open pollinati on in Malabar type	-do-	475 (potl. yield 1000)	Early maturing, suitable for high density planting, bold capsules, oil 8.0"10, 1,8 cineol 45.0%, ɑ-terpenyl 380%
PV1 1991	A selection from Walayar collection, a Malabar type	Cardamom Research Station, RAU, Pampadumpara, Idukki, Kerala PIN 685 553	260 (potl. yi eld 500)	An early maturing type, short panicle, elongated slightly light green capsules, essential oil 6.8%, 1,8 cineol terpenyl acetate *46.0'10*, dry recovery 19.9%
PV2 2001	A selection from OP seedlings ofPV-1, Vazhukka type	-do-	982 (potl. Yield 1250)	Early m sturing, unbranchedI engthy panicle, long bold high dry recovery ercentage (23.8%), essential oil 6.6%, tolerant to stem borer and thrips. Suitable for elevation 1000 to 1200 meters above MSL
ICRI1 1992	Selection from Chakkupallam collection, a Malabar type	ICRI (Spices Board), Myladumpara, Kailas anadu, ldukki (Dist.), Kerala - 685 535	325 (656 kg under irrigate d condition)	An early maturing variety, medum sized panicle with round and extra bold dark green capsules contains oil cineol 29.0"10, a:-terpenyl acetate *38.0'10* and dry
lCRI2 1992	Clonal selection from gerrnplasm collection, Mysore type	-do-	375 (766 kg under irrigated condition)	Performs well under high altitude and irrigated long panicles, oblong bold and parrot green capsules, *aeukkal* disease. Dry recovery 22.5%
lCRI3 1993	Selection from Malabar type	ICRI (Spices Board). Sakleshpur, Donigalpost 573 134, Karnataka	440 (790 kg under irrigate d condition)	Early maturing, non-pubsecent leaves, tolerant to disease, oblong, bold parrot green capsules, suitable for Kamataka, oil 6.6%, 1,8 cineol 54.0%, csterpenyl dry recovery 22.0%
TKD4 1997	Clonal selecti on from Vadagaraparai area of lower pulenys, a Malabar type	ICRl (Spice Board) Thdyankudisai - 624212 TamilNadu	455 (960 kg under irrigated condition)	Early maturity, medium sized panicle, globose bold 6.4%. Suitable for I ow rainfall areas, relatively tolerant rot and capsule borer
IISR Suvasini (CCS-1) 1997	Selection from OP progeny of CL 37 from RRS Mudigere. Malabar type	Indian Insti lute of Spices Research, Cardamom Research Centre (lCAR), Madikeri-571201, Appangal a, Karnataka	745 (1322 kg under condition)	Early maturing, suitable for high density planting, long high % of bold parrot green capsule (89), tolerant to thrips, shoot/paniclel capsule borer, essential oil 8.7%, 42.0%, ce- terpenyl acetate 37.0%, dry recovery 22.0%

IISR	Clonal selection from field	-do-	643 (pot! Yield 979 kg)	Virus resistant s election with high percentage of bol d

Vijetha (NKE-12) 2001	resistant plant for katte, a Mala bar type			(77.0%) oi17.9%, 1,8 cineol 45. CPlo, a-terpenyl acetate dry re cov ery 22.0%. Recommended to moderate moderate high shaded and mosaic infected areas, field thrips and borer as well as mosaic
IISR Avinash (RR-J) 2001	A selection from OP seedlings of CCS-l. a Malabar type	-do-	847 (pot! yield 1483)	Has extended flowering period, dark green c apsul es colour even after processing. Tolerant to rhizome rot, capsule borer, oil 6.7%, 1,8 cineol 30.4%, α - terpenyl 35.5%, dry recovery 20.8%. Highly suitable forplanting and rhizome rot prone areas and intensive cultivation
Njallani Green Gold	A clonal selection from Vazhukka type	Farmers selection from Idukki di strict ofKeral a	1600 (pot!. yield> 3000)	A higher yiel ding clonal selection by a cardam om distri et. Capsules bold, over 70% of the cured mm. Reported to be of high quality. Current!y the cultivar. Yield up to 5000 kglha has been recorded

Propagation

Cardamom is propagated both asexually (through suckers) and sexually (through seeds). Seed propagation is recommended in areas affected by 'Katte' disease (a disease transmitted through suckers) as well as when large number of planting material is to be produced. Vegetative propagation gives earlier bearing and true to type plants. Micro propagation technique has also been standardised and commercialized in cardamom.

Seed propagation

Fully ripe seeds are extracted from ripe capsules from high yielding vigorous plants preferably from 2nd and 3rd round of harvest. Best time for seed capsule collection is September-October. Immediately after picking, capsules are immersed in water and seeds are extracted by gently pressing capsules. Seeds are then washed in water to remove mucilage. Scarification seed with 25 % nitric acid for 10 minutes followed by washing in water before sowing assures 80 % germination. Seeds are then smeared with wood and dried under shade. September sowing is ideal as seedlings are ready transplanting during ensuring planting season.

Primary nursery

Nursery site should be preferably on moderately sloppy land, in open and well drained location near source of water. Raised seed beds (20 cm) of one meter width and of convenient length are prepared. Spread a layer of forest soil over the bed. Soil solarisation of seed beds enhances germination by 25 %, reduces weed growth by 82 % and suppress pests and diseases. Seeds can be broadcasted or live sown 1-2 cm apart in rows 8-10 cm apart. Seed rate is 10 g/m2. On an average, one kg of seed capsules are required to get about 5000 plantable seedlings. Beds are mulched to a thickness of about 2 cm with paddy straw and watered regularly in morning and evening. Sprouting commences in about 25-30 days. After germination is completed, mulch is removed and an over head 'pandal' at a height of 2 m is erected for providing shade. Regular

watering, weeding and plant protection are attended. Thinning of seedlings is done at six-seven leaf state, followed by earthing up.

Secondary nursery

Nursery beds are prepared in same manner as for primary nursery. Shade is to be provided by erecting overhead pandal. Seedlings are transplanted when they are 4-6 months old (4 to 5 leaf stage) at a distance of 20 cm x 20 cm. Beds are mulched and watered regularly. Weeding, manuring and plant protection practices have to be attended whenever needed. One month before transplanting, the overhead shade is removed to enhance tillering. In Kerala 18-22 months old seedlings arE: used for transplanting while in Karnataka 10 months old seedlings are used. Two year old seedlings is the best for getting more tillers and higher yields. The secondary nursery can also be raised in polybags. Polybags of 20 x 20 cm filled with a mixture of humus rich top soil, cow dung and sand (3:1:1) is an excellent medium for filling polybags. Raising seedlings in polybags has many advantages like uniform growth, more tillering and good establishment in field.

Vegetative propagation

Clonal propagation is advantageous in places where 'Katte' disease is not a menace. Also plants raised from rhizomes come to bear early compared to seedlings. Cardamom is propagated vegetatively by division of rhizomes. A portion of the hizome with one old and one young shoot consists a planting unit. The main disadvantage with clonal propagation is limited availability of planting material.

Rapid clonal multiplication technique

A rapid multiplication technique for production of vegetative planting material was standardised at IISR research centre at Appangala, Karnataka. Suckers are collected from high yielding plants and planted at a spacing of 1.8 m x 0.6 m, thus accommodating approximately 6800 plants/ha of clonal nursery area. Overhead shade is provided and nursery is irrigated. Fertilizers at the rate of 48: 48: 96g NPK plant:' is given in two splits. After 12 months of planting, each planting unit produces on an

average 32-42 suckers. In an area of 1 ha clonal nursery, 1 to l.4lakhs planting units can be produced after one year. A crop of 190 g/plant of dry cardamom (1759 kg/ha) also could he harvested within just 19 months of planting. This system is easy and cheap and can be adopted by farmers.

Micropropagation

First commercial level production of plantlets in spice crops through tissue culture was achieved in Cardamom. Micropropagation technique in cardamom was standardised by many scientists. The approaches used were (1) through callusing, (2) through adventitious bud formation and (3) through enhanced axillary branching. Cost effective commercial micro propagation technology developed at ICRI, Spices Board.

Young sprouting tillers of eight to 10 cm length were found as the best explants for tissue culture of small cardamom. Time of collection of the explants is also very important for success of tissue culture of small cardamom. Collection of explants between March to May is ideal. Various media formulations were tested such as LS (1965), Gamborg *et al.* (B5) (1968), MS (1962), KC (1946) and SH (1972). Media were supplemented with various growth regulators such as BAP, KN, IAA etc. Coconut milk was added to every combination tested. Growth factors D-Biotin and calcium pantothenate also were added @ 0.1 mg/I. Hardening of tissue-cultured plantlets was done in sand filled cups under a mist chamber with 80 % relative humidity at a temperature not exceeding 33°C.

Among various media formulations tried, SH was more effective for cardamom shoot inductionsupplemented with BAP, KN and coconut milk each *OS* mg/l and IAA at 2 mg/L Growth factors D-Biotin and calcium pantothenate also were added @ 0.1 mg/I. The buds elongated on M I medium 6-8 weeks, grew to a height of 30-40 mm within 12 weeks. (M I = SH basal + BAP 0.5 mg/l + KN 0.5 mg/l + IAA 2 mg/l + CW(5 per cent V/V) + D-biotin 0.1 mg/l +- Ca. pant 0.1 mg/l).

Transfer of shoots to fresh medium could be done every five weeks, although well established cultures of cardamom appeared to hardly remain in the same medium for up to two months without any deterioration.

When primary cultures were about 30-40 mm long, they were individually transferred to shoot multiplication medium M II (M II = MS basal + BAP 0.5 mg/l +

KN 0.5 mg/l + IAA 2 mg/l + CW 5 pr cent V/V + D-biotin 0.1 mg/l + Ca. pan 0.1 mg/l).

Rate of multiplication ranged from 1:1 to 1:13 with an average of 1:3 per month and the rapidly growing cultures were normally subcultured at an interval of 27-35 days. Although subcultures *could* often be continued over many months and even years without adverse effects apparent in culture, genetically variant shoots could arise through somaclonal variation. To prevent this it was found desirable to initiate fresh cultures from new explants after every 12th subculture. White's rooting medium without any hormones was found more effective than any other media in promoting shoot elongation and subsequent rooting in cardamom. White roots appeared from 4 to 14 days after transferring to rooting medium. The shoots grew rapidly to a length of 50-60 mm during this period. The rooting percentage was 86-93 %.

Rooted shoots that were 4 to 5 cm high and having well-ramified roots were transferred for hardening and acclimatization. Topsoil or a composted soil mixture preferably sterilized or pasteurized was found satisfactory as planting medium. Dipping plantlets in fungicidal solution prior to soil transplanting reduced the risk of damage by fungal attack.

Plantlets were generally allowed to acclimatize in nursery for two to three months till they reached a height of 20-30 cm before transplanting either to polybags or directly to field. Field preparation, planting and culture management were performed according to recommended practices to achieve successful field establishment and subsequent vigorous growth.

Cultivation:

Selection of land, preparation and system of cultivation

The land selected for cultivation of cardamom should be cleared with wild growth and prepare the soil with adequate soil conservation techniques adopted. Normally gentle slope lands or valleys are preferred for cultivation of the crop. Terraces made across the slope at suitable planting distances. Planting distance should be more in high rainfall areas or irrigated condition and less in low rainfall areas. Spacing depends on soil fertility, type of cultivars and terrain. Spacing adopted is more in Kerala while in Karnataka, closer spacing is followed. Spacing of 1.8 m x 1.8 m or 2

m x 2 m is recommended for Malabar variety. 3 m x 3 m for Mysore and Vazhukka. However, in fields of low fertility, plant density can go up to 1600/ha for Mysore and Vazhukka and up to 3000/ha for Malabar. For Karnataka, a general spacing of 1.8 m x 1.8 m is suggested. A spacing of 1.8 m x 1.8 m (3025 plants/ha) and 2.7 m x 2.7 m (1371 plants/ha) is recommended in Malabar and Mysore types respectively in Tamil Nadu. Pits of size 45 cm x 45 cm x 30 cm are dug during April-May, filled with a mixture of surface soil and compost or well-rotten farm yard manure + 100 of rockphosphate. This has to be done two months in advance of planting of seedling for better establishment and good growth. Best season for planting is with commencement of South West monsoon before heavy rains. Cloudy days with light drizzles would be ideal for planting and result in early and maximum percentage of establishment. A void deep planting. A small mound may be formed inside pit to cover the rhizome and immediately after planting mulching should be done. Plants should be supported by stakes. In Karnataka 10-12 months old and 18-24 months old seedlings in Kerala are used for planting in the field.

High density planting

Studies have proved that Malabar varieties perform well under high density planting. Planting of cardamom (Malabar type) with a high density of 5000 plants/ha under rainfed condition in trench system with a fertilizer dose of 120:120:240 kg NPK/ha is recommended for Karnataka state. Studies on high density planting with a spacing of 1.8 x 1.8 m (3025 plants/ha) indicated early and high yields in initial three-four years. However, removal of alternate plants after five to six years is inevitable for facilitating easy cultural operations. Variety Mudigere-l (Malabar type) is the best suited for high density planting (1 m x 1 m spacing). A closer spacing of 1 m x 1 m for Malabar types gave higher yields closely followed by 1.5 m x 1.5 m spacing under the rainfall conditions of Shevroy hills in Tamil Nadu. Planting of suckers at a spacing of 1.8 m x 0.9 m gave considerable high yields in initial stage. Mysore and Vazhukka varieties are not suitable for high density planting.

Shade management

Cardamom is a pseophyte, it requires filtered light of 50-60 percent for better growth and yield. Shade management is an important operation in cardamom plantation. Shade trees having distributed branching pattern and small leaves are ideal for cardamom. The ideal shade tree in cardamom plantation should have the characteristics of Wide canopy so that number of shade trees in unit area is minimum, No shedding of leaves during flowering phase so that pollination is not affected, Medium size and evergreen in nature retaining their foliage throughout the year, Should have small leaves and well spread branching system, Should have deep root system to avoid competition with cardamom and to resist wind and Should be fast growing to provide necessary immediate shade.

It is desirable to maintain a mixed population of medium sized trees that facilitate shade regulation and maintain more or less optimum conditions throughout the year.

Some of the good shade trees suited are *Vernonia arborea* (Karana), *Cedrella toona* (Red ceder), *Cassia fistula* (Kanikonna), *Diospyros malabaricum* (Vellakil), *Terminalia tomentosa* (fhempavu), *Hopea pannflora* (Thambakam), *Acrocarpus [raxinifolius* (Balangi), *Mesopsis eminii* (Elangi) and *Artocarpus integrifolia* (jack), Shade trees like red cedar, which shed their leaves in monsoon, provide natural shade regulation. Protection from sunlight by maintaining an overhead tree shade is essential for cardamom in the initial stages of growth to enhance tillering. In newly established plantations, where shade is inadequate, fast growing species of *Eruihrina* may be planted along with other trees. After the establishment of shade trees, erytrina may be removed. Similarly, shade should be thinned during monsoon and premonsoon period. In order to provide adequate sunlight during rainy season (when light intensity is less), excess shade should be regulated before onset of monsoon. Shade regulation studies on cardamom productivity revealed that one third of incident sunlight (15.20 K Lux) in the form of filtered light is optimum for growth and production. Studies at RRS Mudigere (University of Agricultural Sciences, Bangalore) revealed that shade trees in cardamom plantation play an important role in nutrient recycling through leaf fall. *Theoeiia nerifolia, Terminalia catapa* and *Artocarpus integrifoiia,* produced more biomass around 950 g/m^2/year. Jack tree is found to recycle maximum NPK (63.9kg/10 tonnes

biomass). A study conducted at Cardamom Research Station, Pampadumpara to assess organic carbon content of CHR dominated by different tree species was given by Miniraj and Murugan (2000). In the undisturbed ecosystem, organic carbon content of soil was high (Table 14). Comparatively higher organic carbon content was recorded in cardamom production systems as compared to that black pepper. This is clearly attributed to lack of native tree species and low biomass production of dominant tree - *Erythrina.* Besides, warmer soil environment experienced in pepper production system due to shadeless condition directly and indirectly affect decomposition of organic matter. Cultivation of cardamom under artificial shade (coir mat) is economical and feasible.

Manures and Fertilizers

Cardamom requires regular manuring and fertilizers for better growth and yield. Organic manures like compost or cattle manure may be given @ 5-10 kg/ clump. Neem oil cake may also be applied @ one kg/ clump. Nutrient uptake studies indicated the uptake of N, P, K, Ca and Mg in the ratio of 6:1:12:3:0.8 respectively. Cardamom is a heavy feeder of potash. For crop yielding 100 kg dry capsules/ha, an optimum fertilizer dose of 75:75:150 kg NPK/ha (half the dose for one year old plant) in two split doses is recommended for Karnataka. Cardamom is a surface feeder. Roots are generally confined to surface soil and nearly 70% of roots are with in 5 cm depth. Therefore fertilizer is to be applied in circular bands of 15 cm width leaving a distance of 30 cm from plant base. First application during May-June helps production of suckers and development of capsules and second application during September-October helps initiation of panicles and suckers. In irrigated plantation, application of fertilizers in 4 split doses at quarterly interval is beneficial. Higher levels of fertilizer viz., 150:150:225 kg NPK/ha resulted in significant higher capsule yields at Mudigere (Karnataka). Evaluation of optimum fertilizer levels for high density cropping studies conducted at Mudigere confirmed that cardamom grown under natural shade responded positively for fertilizer application and significantly influenced yield. Mudigere (Karnataka) and Pampadumpara (Kerala) have come out with independent fertilizer recommendations viz. 75:75:150 kg NPK/ha and 100:100:175 kg NPK/ha respectively. While the fertilizer recommended for Tamil Nadu is 40:80:40 kg NPK/ha during June, August and November. For low rainfall areas of Tamil Nadu,

recommendation is 20:40:20 kg NPK/hain two splits during September and November. Fertilizer dose of 120:120:240 kg NPK/ha is recommended in high density planting of (5000 plants/ha) Karnataka. At Mudigere, studies on integrated nutrient management using organic and inorganic manures on yield of cardamom confirmed that 100% inorganic manure alone recorded maximum green capsule yield (707 kg/ha). Studies also confirmed that boron and molybdenum play an important role along with other management practices in increasing yield. Application of boron in the form of disodium tetraborate @ 20 kg/ha and molybdenum in the form of sodium molybdate @ 0.25 kg/ha mixed with appropriate quantity of FYM @ 1 kg/ plant applied with onset of monsoon increased cardamom yield by 20%.

Deficiency Symptoms:

Nitrogen: Yellowing of older leaves, reduction in leaf size and sucker production and drying of new suckers.

Phosporous: Perplish spots, premature falling of older leaves, stungted plant growth, reduced number of suckers and roots.

Potash: Browning of leaf tips, whole leaf turned dark brown, no new sucker production, reduction in root and shoot growth.

Calcium: Leaves become brittle, reduction in size, no new growth of aerial shoots, root and shoot growth restricted, bulky appearance.

Magnesium: Tip drying, twisting of stunts, root and shoot growth affected, vein clearing and Yellowing of leaves.

Mulching: It is on important operation to conserve soil and moisture, fallen leaves of the shade trees are utilized for mulching around the space of the plant. Five centimeter thickness of mulching is advisable. Mulching should be done during the month of November-December to overcome the ill effects of drought, which is prevailing during summer. Mulching helps in conservation of moisture and helps for better growth of the plant. Any locally available mulch materials (Dry leaves, grass, phoenix leaves etc.,) and polythene sheets can also be used as mulch materials.

Liming:

Cardamom is cultivated in heavy rain fall areas of hilly region, top soil along with nutrients or eroded as a result soils are becoming 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 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.

Irrigation

Cardamom is sensitive to moisture stress and needs irrigation during summer. Irrigation at an interval of 10-15 days from December till commencement of monsoon is required. Analysis of rainfall pattern of 50 years in cardamom growing tracts by ICRI, Spices Board recommended that judicious irrigation during peak dry months (February to April) ensures increased yield. This is the period when development of young tillers and elongation of panicle take place. Water stress during this period of growth result Ll1 reduced yield. Anyone of the methods viz. sprinkler, drip or hose irrigation could be adopted. Taking into account the crops consumptive use and climatic condition, it is recommended that irrigation is given at an interval of 10-12 days to get the equivalent of 25 mm rain in each round. Cardamom plants are also sensitive to water logging. Hence, excessive irrigation is also detrimental, Combination of irrigation at 75 % available soil moisture level and high light intensity (65 to 70% lux) resulted in sustained increase in yield. Irrigation through drip method four litter per plant per day is recommended.

Use of growth regulators

Exogenous application of NAA (40 ppm) or 2,4-D (4 ppm) increased plant height and panicle production. Similarly, spraying of NAA (25 ppm) twice (June and July) reduced fruit drop and increased fruit set. Application of ethrel (250 ppm) under high light intensity (15 K lux) doubled sucker production.

Bee-keeping

Pollination in cardamom is entomophilous mainly by two species of honey bees viz. Apis cerana and Apis dorsata. Honey bees contribute over 90% pollination, lack of pollination causes fruit drop and fruit set in cardamom. Number of visits of bees is directly correlated with the number of seed formed in capsules. Five to six visits by bees are required for getting full seed set. At least four bee colonies (hives) / ha to are needed to enhance pollination and fruit set. Increase in yield up to nine % could be obtained by keeping bee

hives. Soil and moisture conservation, the economic life span of cardamom crop is 10-15 years under good growth condition without severe pests and diseases. Conservation of soil and water should be taken care in hill slopes. Measures like contour trenching, bunding, bench terracing, drain channels, check dams and afford station are recommended. Intensive tillage of soil leads to soil erosion.

Weeding :

Two to three weedings are required in a year depending on the weed growth. First weeding may be done in May-June before the fertilizers of application. Second weeding is done in August-September before the post monsoon application of fertilizers. It is very important to carry out the third round of weeding in November-December soon after the North-East monsoon is over for avoiding the competition of weeds for moisture and nutrients. Weedcides like paraquat (Gramoxone) 1.25 liters per hector could be used to overcome the weeds.

Exposing of panicales :

From first week of June onwards exposed panicales by lifting them above the layer of mulch to facilitate the visiting of bees for pollination. This operation has to be followed 2 to 3 times in a cropping period.

Earthing up operation:

After the monsoon is over a thin layer of top soil is earthened up to the base of the clump covering upto the collar region by scrapping between the rows or obtaining the soil from the trenches or check pits, which encourages the new growth and sucker production.

Trashing :

Clean the plant by removing old suckers, dry leaves etc., once in a year in May-June It helps for better production of suckers and to reduce pests and diseases.

Harvesting and processing

Cardamom plants start bearing fruits (capsules) from 2-3 years after planting and satisfactory yield is obtained from 5th year. It takes 110 days from flowering to fruit maturity. Harvesting season is in August-December; peak harvest is during October-November. Capsules are harvested at an interval of 15-20 days at Karnataka and 30 days in Kerala and harvesting will be completed in seven-eight rounds. Fruits that are just ripened or physiologically mature (at the black seeded stage) are picked by experienced

workers. If capsules are immature, they will have a wrinkled appearance on curing and if they are fully ripe they will split on curing and will develop an yellow colour. Essential oil content will be more at physiologically mature stage and dry recovery more at ripened stage. At physiologically mature stage, recovery is 24 %.

Two types of pickings are adopted - light picking and hard picking. In light picking, only mature capsules are harvested whereas in hard picking semi-mature crop is also removed. Choice depend on availability of labour. Cardamom harvesting is mainly done by women labourers. The average yield of dry capsules is ranged between 200-500 kg/ha.

Quality parameters of cardamom

Boldness and colour of cured capsules, content and organoleptic character of volatile oil are important quality parameters of cardamom. They are primarily dependent on cultivar and time of harvest. Malabar is superior with regard to flavour and quality whereas Mysore dominated in production of bold green capsules.

Green Cardamom

Colour of cured cardamom is an important factor in consumer market. The highest quality cardamom traditionally was Aleppy Green, which is still regarded as the best. Different chemical treatments were tried to retain green colour of harvested capsules. Among such treatments, soaking green (wet) capsules immediately after harvest in two per cent sodium carbonate solution for 10 minutes fixes green colour during subsequent drying and storage. Except sun drying, all other methods are found to protect the green colour.

Post harvest operations

Post harvest operations consist of washing, curing (drying), cleaning, polishing, sorting, grading and packing. The capsules immediately after harvest are washed in water to remove adhering soil. Sometimes, capsules are treated with 2% washing soda (sodium carbonate) for 10 minutes to stabilize chlorophyll and this treatment imparts better green colour.

Curing

Cardamom curing may be defined as process in which moisture content of freshly harvested cardamom capsules is reduced from 80 % to 11-12 % at an optimum temperature of 45-55°C to retain its green colour and volatile oil to a maximum extent (Vadiraj, 2004). There are mainly two types of drying in cardamom viz. natural (sun drying) and artificial (firewood, electricity, kerosene or LPG as fuel).

Sun drying

Harvested capsules are directly dried under sun for '-' period of five to six days. Sun dried capsules will be bleached in appearance. Splitting of capsules will be more. This method is prevalent in some parts of Karnataka.

Flue pipe curing

It is one of the best methods of drying by which high quality green cardamom can be obtained. Hand picked fruits are dried in special curing chambers under controlled temperature to retain delicate flavour and green colour. Heat required for drying is produced by burning fire wood in iron Kiln, the heat thus produced is passed through pipes made of galvanized iron sheet. Capsules left for drying are spread thinly on wire net trays arranged one above the other on racks in the upper chamber of the curing house. They are stirred frequently to ensure uniform drying and also help to retain green colour of capsule. Drying temperature is kept at 50°C for first 4 hours and subsequently reduced to 45-50°C by opening ventilators and using exhaust fan. Finally temperature is raised to 60°C for one hour. The process of drying takes about 36-48 h.

Dried capsules are rubbed with coir mat! gunny cloth/ steel mesh and sieved to remove other plant debris. This process is called polishing. Polishing is also done in machines. The polished capsules are then graded according to size by passing through sieves of size 7, 6 and 5 mm. They are sorted according to size and colour. The percemage recovery is 24. The graded produce is packed in polythene lined gunny bags. Bin drier designed by UAS, Bangalore (electricity based), Melccard drier used in Bodinaikkenur region in 'I'amil Nadu (firewood operated), Solar drier developed by CPCRI, Kasaragod (solar energy as fuel), Mechanical cardamom drier developed by RRL, Trivandrum (electricity as energy), and thorough flow drier fabricated by CFTRI (electricity as energy source) are some of the new generation driers available. Kerosene. LPG gas and biogas were successfully used as an alternate fuel source in cardamom curing especially in the fire wood deficient areas and also by small and marginal growers. The kerosene and LPG based system were standardised for small quantity of 50-100 kg capacity (Vadiraj, 2004). These systems are not only ecofriendly but economical also.

Bleached cardamom

Bleached cardamom is manufactured in some parts of Karnataka. It is creamy white or golden yellow in colour. Bleaching can be done either with dried capsules or fresh capsules. Fresh capsules are soaked in 20 % potassium metabisulphite solution containing one % hydrogen peroxide for one hour. Drying of these capsules yield golden yellow colour. For dry capsules, bleaching agents used are bleaching powder, sulphur dioxide, potassium metabisulphite and hydrogen peroxide. In the conventional method prevalent still in Karnataka, bleaching of cardamom is carried out by steeping dried capsules in soap nut water *(Sapindus saponaria).* Bleached cardamom is inferior in quality (low volatile oil content) but its keeping quality is slightly better.

Cardamom seed and powder

Cardamom seeds are obtained by decorticating capsules. Cardamom powder is obtained by grinding seeds.

Value added products

Cardamom oil

Produced commercially by steam distillation of crushed fruits or powdered seeds of cardamom. Oil percentage is 8-11. Main flavour components of the oil are 1,8-cineole, a-terpinylacetate, linalyl acetate and linalool. Relative proportions of these constituents have a direct bearing on cardamom quality. Cineole is responsible for camphoraceous odour while other esters and alcohols give pleasant fruity odour.

Cardamom oleoresin

Oleoresin is obtained by solvent extraction. Of late, super critical fluid extraction is also adopted (SCFE). Oleoresin is produced in a relatively small scale only.

Fixed oil of cardamom seeds : Obtained from seeds. Major constituents of oil are oleic and palmitic acids.

Grading of cardamom Specifications for Indian cardamoms are given below:

Grade	Description	Size	Weight (gIl) min	Colour	General characteristics
AGAlleppe Green					
AGB	Extra bold	7	435	Green	Kiln dried
AGS	Superior	5	385	Green	3 cornered and with ribbed appearance
AGSl	Shipment	4	320-350	Light	
AGL	Light	3.5	260	green	
CG Coorg Green					
CGEB	Extra bold	8	450	Golden to light green	~
CGB	Bold	7.5	435		Round, ribbed or smooth

CG-1	Superior	6.5	415	Light Green Green	
CG-2	Mota, green	6	385	Cream	
CG-3	Shipment	5	350	Brown	
CG-4 Bleached bleached)	Light	3.5	280		
BL-1		8.5	340	Pale	Fully developed
BL-2		7	340	Creamy or smooth	round/3 cornered ribbed
BL-3		5	300	Dull white	

Agmark grades are also available for Coorg Cardamom and Bleached Cardamom.

LARGE CARDAMOM

Scientific Name : *Amomum subulatum Roxb.*

Family : *Zingiberaceae*

English Name: Large Cardamom, Greater cardamom, Nepal cardamom

Indian name : Badi Elaichi

Large or greater cardamom is also known as Nepal cardamom and is an important spice crop of India. The seeds of large cardamom, which are commercially important. The volatile oil present in the seeds of large cardamom is one of the principle constituents responsible for its typical characteristic odour. The volatile oil is pale yellow in colour and consists of (in%) oc-pinene (2.0), f3-pinene (2.4), sabinene (0.2), myrcene (0.3), oc-terpinene (0.2), limonene (10.3), 1,8 cineole (74.0), y-terpinene (0.2), r-cymene (0.2), terpin-4-d (2.0), d-terpineol (5.6) and nerolidol (1.0).

Due to its pleasant aromatic odour, large cardamom is used for flavouring various vegetables and meat preparations. It is also used as a flavouring agent in confectionery, hot or sweet pickles and in beverages. The seed is used as an essential ingredient in mixed spice preparations. The ripe fruits are eaten raw by the inhabitants of Sikkim and Darjeeling during September and October.

The seeds have a sharp, good taste and are a tonic for heart and liver. They are an astringent to the bowels, are hypnotic, appetizing and aid digestion. The outside covering is good for headaches and for the teeth and heals stomatitis. The decoction of the seeds is used as a gargle to cure problems of the teeth and gums. In combination with melon seeds, they are used as a diuretic in case of kidney stones. In certain disorders of the digestive system, marked by scanty and viscid secretion from intestines, they promote elimination of bile and are useful in congestion of the liver. The seeds are used in treating gonorrhoea and as an aphrodisiac. They have also been found useful for the cure of neuralgia, in large doses in conjunction with quinine.

The seeds are used as antidotes to snake or scorpion venom. The seeds are also widely used in India as a spice or condiment and in the preparation of sweets. In medicine, they are fragrant adjuncts to other stimulants, bitters and purgatives. The oil extracted from the seeds is applied to the eyelids to allay inflammation. It is an aromatic cardiac stimulant, stomachic, diuretic, carminative and is a remedy for throat and respiratory ailments. Large cardamom is native to the moist, deciduous and evergreen forests of the sub-Himalayan region. It is an important crop of Sikkim from where it has spread to the North-eastern states and parts of West Bengal, Assam and neighbouring countries like Nepal and Bhutan.

Origin and Distribution:

The large or Nepal cardamom is indigenous to Sub-Himalayan region. Sikkim, West Bengal, Nepal, Arunachal Pradesh, Himachal Pradesh and Uttaranchal are the important states cultivating large cardamom in India.

Area and production

Sikkim is the leading state in area (26,151 ha) and production (4,200 t) followed by Darjeeling in West Bengal. Arunachal Pradesh, parts of Himachal Pradesh and the Garhwal hills of Uttaranchal have just initiated its cultivation with the present average yield being only 160 kg/ha. The bulk of the large cardamom produced is consumed in the country and a limited quantity (about 775 Mt) is exported to Singapore, Pakistan and the United Kingdom. Among the other countries, Bhutan produces about 3000 to 3400 Mt and Nepal around 1000 Mt of large cardamom annually.

Botany:

Large cardamom is a herbaceous perennial with subterranean rhizomes, which gives rise to leafy shoots and spikes. The mature plant height ranges from 1.5 to 3.0 m. Leafy shoots are formed by long sheath-like stalks encircling one another. The leaves are green or dark green, glabrous on both the surfaces, with an acuminate apex. The inflorescence is a dense spike on a short peduncle bearing 40 to 50 flower buds in an acropetal sequence. The fruit is a trilocular, many- seeded capsule. The capsule wall is echinated and is reddish-brown to dark pink in colour. Wild species of Amomum also exist in Sikkim.

Soil and Climate

Large cardamom is a shade-loving plant (seophyte) and grows luxuriously from 600 to 2300 m above sea level in a humid, subtropical natural habitat on slopes under the canopy of lofty, evergreen forest trees. Moderate shade, high humidity and cool surroundings are essential for its satisfactory growth and production. The temperature varies from 10-30°C in the growing areas. The average annual rainfall ranges from 200 to 350 cm spread around 200 days. It is highly sensitive to wind and drought.

The crop grows best on well-drained, rich forest soils with plenty of humus and leaf mould. Since the plant has a lot of surface feeding roots, the soil should essentially be well-drained. Cardamom plantations established on rich and well-drained soils, besides giving

higher yields, maintain their productivity for a considerably long period, sometimes for more than 20 years. Water-logged areas are not suitable and hence adequate drainage is essential for better growth along with a pH of 5.8 to 6.5.

Species of Large Cardamom

SPECIES	COMMON NAME	COUNTRY	USES
A. aromaticum Roxb.	Bengal Cardamom or Nepal cardamom	Eastern india, Pakistan	Rhizomes are used as a spice and flowering shoots are used in curries
A. compactum soland	Round cardamom	Malaysia, Java	Fruits are used as spice
A. glabosum Cour	Round Chinese Cardamom	China	Seeds are used as spice
A. krevanw Pierre	-	Cambodia, Indo-China	Fruits are used as spice and to flavour curries sausages and cordials
A. maxiumum Roxb.	Java Cardamom	Malaysia	Used as spice
A. xanthiodies Wall.	Wild bastard Siamese Cardamom	Myanmar, India	Used as spice

Varieties

There are mainly 6 varieties of large cardamom. In addition, there are several sub-varieties or strains which are named in the local dialects of Lepchas, Bhutias and Nepalese. These varieties are *Bebo, Bharlangy, Golsey, Ram/a, Ramsey* and Swaney. Among these, three popular cultivars grown in Sikkim are *Ramsey, Sawney* and *Golsey.* Other cultivars are derivatives of these varieties. These cultivars are white Ram/a, *Chivey Ramsey, Garday Seto* Ramnag, Madhusay (Madhusai), *Seto Golsey, Slant Golsey, Red Sawney* and *Mingney.* The same cultivar is called by different names in different localities, as variations in growing conditions cause changes in plant colour, whereas, harvesting at different stages of fruit development changes the fruit- skin colour.

The characters of the three major cultivars are

Ramsey or Ramsmey

It is a Bhutia word which means yellow colour (ram—colour, *shai* or sey-yellow). Plants of this cultivar are tall (approx. 2.5 m) having many shoots (10-15) with thin and long leaves. The fruits are the smallest in size and are of inferior quality. The cultivar is grown mostly on higher altitudes (around 1,500 m and above). In lower altitudes, the plants are severely affected by the Forkey virus disease.

Sawaney or Sawney

This is a Nepali word which means that the cultivar is harvested in sawan, i.e., August. The plants are tall (approx, 2.5m) but the leaves are wider and shorter compared to those of

Ramshai. The fruits are bold in size and brown in colour. This cultivar is very popular in the lower altitudes (below 1,500 m) as it is comparatively less susceptible to the Forkey virus disease.

Golshai or Golsey

This is a derivative of the word golraund in Hindi and shai or seyyellow (Bhutia), indicating the round shape and yellow colour of the fruits. The plants are short with fewer shoots (5-6). The leaves are comparatively short and broad. The fruits are big and bold and are sold at premium prices because of their good appearance. The salient features of different cultivars, studied at the ICAR Complex for NEH Region and Sikkim are given in the table below.

Salient characters of large cardamom cultivars

SI.No.	Particulars	Golsey	Sawney	White Ramna
1.	Number of bearing shoots per clump	11.4	25.2	21.0
2.	Number of flower panicles per clump	5.8	12.2	26.0
3.	Number of capsules per panicle	8.9	9.9	7.1
4.	Total number of capsules/clump	51.6	120.8	185
5.	Weight of fresh capsules/clump	243.6 g	263.8	425.5 g
6.	Weight of dry capsules/clump	50.0 g	64.1 g	98.0
7.	Single fresh capsule weight	4.7 g	2.1 g	2.3 g
8.	Single dry capsule weight	0.97 g	0.53 g	0.53 g
9.	Number of plants/ha	12.345 (90x90 cm)	6.410 (1.25 x 1.25 m)	6.410 (1.25 x 1.25 m)
10.	Total weight of dry capsules/ha	617.8 kg	410.8 kg	628.6 kg
11.	Volatile oil content	2.8%	1.8%	1.5%

Dried capsule characters of large cardamom

Cultivars	Av. Weight of 100 capsules (g)	Av. Number of seeds/ capsule	Length of capsule (mm)	Diameter of capsule (mm)	Remarks
Red Sawney	64.00	40	20.6	13.5	Large –sized, greyish-brown capsules, with seeds of dull brown colour and moderate pungency
White Green Golsey	77.0	46	20.3	12.4	Medium to large-sized dark black capsules, with black seeds and high pungency
Sawney	54.3	38	19.9	12.1	Medium –sized, light brown capsules with brown seeds of lesser pungency. The volatile oil content of the seeds is 1.8-2.5%
White Golsey	80.0	59	22.0	14.0	Large-sized, pinkish-brown capsules with large black seeds of high pungency
Golsey	104.0	58	23.3	14.8	Large-sized. Roundish, brown capsules, with light brown seeds that are highly pungent. The seeds contain 2-3% volatile oil.
White Ramna	53.0	24	17.0	10.0	Small-sized, yellowish capsules with light grey seeds of less pungency.

Five promising types of large cardamom, *viz.*, ACC. No-3 (Ramea from Singhik), ACC. No.-4 (Romeo from Singhik), ACC. No.-9 and (Ramasey green type), ACC. No 12 (Burlangey) ACC, No 14 (Bebo) and five relatives, viz., Churumpa *(A. dealbatum), Baklok (A. kingii), Belak, Tali* and *Jaker* (all Amomum *sp)* have been identified from 34 germplasm types maintained at the experimental farm of the ICAR complex at Tadung, Sikkim.

Two high yielding varieties ICRI Sikkim-1 and ICRI Sikkim-2 (belonging to Sawney cultivar) were released from Regional Research Station, Sikkim for large cardamom. Yield of these two varieties are 800-900 kg/ha under rainfed condition.

Cultivation

Propagation

Large cardamom can be **propagated** by seed as *well* as by vegetative methods. The seedling plantation starts bearing fruits after five years, whereas plants raised by rhizomes start bearing after three years of planting. Therefore, the vegetative method is preferred for

the commercial plantation of large cardamom.

Vegetative propagation

Large cardamom is generally propagated by planting a section of the rhizome, called a bulb or slip, from an established clump. Care should be taken to select rhizome slips only from disease-free, healthy and high-yielding mother plants. The plants propagated by this method come to the yielding stage two years earlier than those grown by seed propagation. However, repeated vegetative propagation reduces plant vigour and hence should be avoided.

Seed propagation

Seeds and sowing

The seeds for sowing in the nurseries should be collected from well- matured capsules selected from high-yielding mother plants. The capsules are dehusked just after harvesting and the seeds are thoroughly washed in water to remove the mucilage coating. The seeds are then mixed with wood ash and dried in the shade for 2 to 3 days. Now the seeds are ready for sowing. Generally, about 30 to 50% germination is obtained in large cardamom. To increase the percentage of germination, treating the seeds with concentrated sulphuric acid for 2 minutes or concentrated nitric acid for 10 minutes is advised.

Primary nursery

Beds of 5m x lm and about 15 cm to 25 cm in height are prepared. A thin layer of humus-rich jungle soil is spread on the beds. The seeds are sown in lines about 10 to 15 cm apart. They are covered with a thin layer of fine soil and the beds are mulched with paddy straw or any other dried grass to a thickness of 2 to 3 cm. The beds are irrigated daily to keep them moist. The mulch should be removed after germination and the beds should be kept free of weeds. There are two seasons for sowing the seeds: pre-winter (October-November) and post-winter (February-March). The seeds sown in October- November remain viable till the end of winter and start germinating in March. However, it is observed that the seedlings obtained from the pre-winter sowing are healthier and more vigorous compared to the post-winter sowing, hence pre-winter sowing of seeds is preferred. *Pandals* (thatched structures) may be provided to protect the seedlings from the sun. Regular weeding and watering should be done. The seedlings are ready for transplanting in June-July.

Secondary nursery

Here, the beds are prepared as in the primary nursery. The seedlings are transplanted to these beds in rows at spacing of 10 cm between plants and 15 cm between rows. After about 12 months, the seedlings will be ready for planting in the main field.

Land preparation

Virgin forest areas, if selected for plantation, should be cleared of all undergrowth and trees not suitable for the relatively heavy shade needed by cardamom. Where the tree growth

is sparse and shade insufficient or unsatisfactory, quick-growing trees are planted for temporary shade as well as other trees with a tall and spreading habit for permanent shade. The trees selected for providing permanent shade in cardamom plantations should have the following characteristics:

1. A tall and fast-growing habit, so that within 3 years of planting the tree attains sufficient growth to provide shade for the already-flowering cardamom plants.
2. The tree should provide maximum shade during the dry period.
3. The tree should provide maximum shade during the dry period.
4. The leaves should decompose quickly when they fall on the ground.

Utis (Alnus nepalensis) has been recommended as an ideal shade tree. Other important shade trees are Chillowne, *Schima* wallichi, pan isaj, Bucklandea populnea, Malato, Macaranga denticulate and Edgeworthia gardneri. The shade trees are planted with a spacing of 7-10 m.

Planting

Bulbs or slips or seedlings along with 1-2 shoots are planted in the prepared pits (30 cm x 30 cm) at 150 cm x 150 cm distance for Ramshai and Sawane[y] and at a 90 cm x 90 cm distance for *Golshai*, by digging a hole in the soil. The plantin[g] is done at 8-10 cm depth. After a few showers, the pits may be filled with surface soil. Well- rotten cattle manure, compost or leaf-mould should be mixed thoroughl[y] with the top soil before planting. It is also advisable to add 100 g rock phosphate per pit and mix it with the top soil before filling the pits. Planting is done in June-Jul[y] when there is sufficient soil moisture, atmospheric humidit[y] and optimum temperature for growth.

Mulching

Soon after the planting, the base of the plant should be mulched during November-April with dried leaves. Mulchin[g] will preserve the soil moisture and provide a source of nutrients after decomposition. Organic manures like FYM, compost, leaf-mould and humus, rich forest soil may be applied. As the soil is rich, generall[y] no fertiliser is recommended.

Manures and fertilisers

As the inherent capacit[y] of the soil to supply nutrients is high due to the presence of high organic matter, fertilisatio[n] is not a common practice in cardamom. But it has been observed that the application of 30 kg N along with 30 tonnes of FYM or compost per hectare every year increases the yield of large cardamom. Wood ash is also effective. About 10 kg cowdun[g] manure or compost along with 10 g N and 25 g superphosphate per clump are added each year for higher production.

Irrigation

Irrigation may be provided once in every 10 days during December Large plantations

require regular weeding during the first (3-4 times) and second (2-3 times) year of planting and, thereafter, the problem lessens as the foliage covers the entire field. The intensity and frequency of weeding depends upon the weed species, population and diversity. Weeding by scraping the soil surface is a common practice and it should be discouraged because it adversely affects the soil structure. Instead, weed threshing should be carried out twice a year once during May-June and the second time before harvesting.

Shade regulation

Tall growing trees are trimmed regularly to a height of 4-5 m to encourage the spreading habit with renewed vegetative vigour to provide uniform shade and higher quantity of leaf-litter.

Re-planting

Large cardamom starts bearing from the 3rd year after the final transplanting into the main field and continues to yield up to 25 to 30 years; but the economical production period is from the 5th to 10th year after which the yield decreases. Thus, replanting has to be done after the $_{9}$th year, gradually, as it is difficult and uneconomical to destroy the entire plantation at one time. However, the removal of the entire plantation is resorted to when virus diseases appear

Harvesting and yield

The crops raised by seeds start fruiting after 5 years, while vegetatively propagated crops fruit after 3 years of planting. Flowering starts from April-May and continues up to June-July. After fertilisation, the fruits ripen within 5-6 months. Harvesting is done by cutting the mature panicles with the help of a long narrow knife. The harvesting span is between August and November. The economic yield period varies between 12-15 years; however, some well-managed plantations can yield profitably up to 20 years. During the third year, when the first harvest is done, the yield is negligible (<25 kg/ha). The yield gradually increases and reaches the maximum in the sixth or seventh year. The yield at this stage varies greatly (3 to 10 q/ha of dry cardamom), depending on the management.

Curing

The fruits are separated from the harvested panicles for drying and curing. The freshly-shelled fruits are dried on a kiln. Over the kiln, a thin bamboo structure, just like a mesh, is placed, on which the freshly- harvested fruits are spread out for curing. Wet and freshly-cut wood which does not burn well and gives out a lot of smoke is used for fuel in the kiln, so that temperature does not rise too high. For good curing, a low temperature is required. Once the kiln is started, it takes about three days of continuous smoking for complete curing or drying. A kiln of 2.4 x 2.4 x 2.4 m has the capacity to dry 12 bags (40 kg each) of fresh fruits. Approximately 25% of the fresh weight of the fruits is recovered after the drying is completed. The dried capsules are dark pinkish-brown in colour and have a smoky odour and the dried material cannot be stored for a long time. The flue-pipe system of curing may be used as it is better than the kiln system, since the colour of the capsules

remains a shiny pink in the former method. In this system, a flue from the furnace passes through the pipes. The harvested wet cardamom is spread over wire meshes fixed above the flue pipes. The product is dried by the movement of hot air. It takes about 24-30 hours for the produce to dry. The cardamom cured by this system retains its colour and flavour, which fetches a good price in the market.

Storage

The cured produce needs to be packed in insect-proof bags. Coal-tar coated and polythene-lined gunny bags are effective against insect attack during storage.

Value-added products

The value-added products of large cardamom are the essential oil of the seeds and the oleoresin.

REFERENCES:

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
5. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
6. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
11. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micro-propagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
12. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
13. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
14. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.

15. Pruthi, J.S., 1989, Major Spices of India, Crop management Post-Harvest Technology, published by *Indian Council of Agricultural Research*, New Delhi.

Small Cardamom

Questions:

I. Choose the correct answer in the following:

1. *Elettaria cardamomum* is the botanical name of

a) Black pepper b) Small cardamom c) Large Cardamom d) Zinger

2. Small cardamom belongs to the family

a) Cucurbitaceae b) Cruciferae c) Zingiberaceae d) None of these

3. Single capsule of small cardamom contains

a) 1-2 seeds b) 15-20 seeds c) 100-150 seeds d) > 250 seeds

4. Vijetha (NKE-12) is a virus resistant variety of

a) Small cardamom b) Turmeric d) Garlic d) Cassava

5. Katte disease in small cardamom is transmitted through

a) Suckers b) Tissue culture plants c) both a and b d) None of these

6. Life cycle of small cardamom is

a) Annual b) Biennial c) Perennial d) None of the above

7. Breeding behaviour of small cardamom is

a) Self pollinated *b) Cross pollinated* c) Often cross pollinated d) None of these

8. Average yield of dry capsules in small cardamom is

a) 200-500 kg/ha. b) 2-5 t/ha. c) 5-10 t/ha. d) 10-15 t/ha.

9. The botanical name of large cardamom is

a) Amomum subulatum b) *Elettria cardamomum*
c) *Cardamom esculentum* d) None of these

10. Ramsey, Sawney and Golshai are three major cultivars of

a) Small cardamom b) Large cardamom c) Zinger d) Turmeric

11. Large cardamom can be propagated by

a) Seed b) Rhizome slip c) both a and b d) None of these

12. Germination percentage of large cardamom is

a) Approx 40 % b) Approx 80 % c) Approx 90 % d) Approx 95 %

13. First harvest in large cardamom can be obtained after

a) 1 year b) 3 years c) 6 years d) 10 years

14. Origin of large cardamom is

a) India b) USA c) Mediterranean region d) Ethiopia

15. Single inflorescence of large cardamom contains

a) 2-5 flower b) 8-10 flowers c) 40-50 flowers d) 100-150 flowers

II. State whether true or false :

1. Small cardamom is a shade loving plant.
2. Small cardamom has its origin in India.
3. Small cardamom needs high temperature (more than 40^{o}C) for its growth.
4. Malabar, Mysore and Vazhukka are major cultivated types of small cardamom.
5. According to the studies, Malabar varieties do not perform well under high density planting.
6. Small cardamom is a surface feeder.
7. NAA sprays help in increased fruit set.
8. Optimum soil pH for successful growth of cardamom is less than 4.5.
9. 'Trashing' is the process of removing old suckers and dry leaves to promote better production of new suckers.
10. Hot sun drying of small cardamom after harvest helps in retaining attractive green colour of small cardamom.

III. Match the following:

Part-A		Part-B	
1	Queen of spices	a	Prostrate type
2	Badi Elaichi	b	Erect
3	Malabar variety of small cardamom	c	Small cardamom
4	Mysore type of small cardamom	d	Semi-erect
5	Vazhukka type small cardamom	e	Large cardamom

Answers:

I main		II main		III main	
Sl No	Answers	Sl No	Answers	Sl No	Answers
1	**b**	1	**T**	1	**c**
2	**c**	2	**T**	2	**e**
3	**b**	3	**F**	3	**a**

4	**a**	4	**T**	4	**b**
5	**a**	5	**F**	5	**d**
6	**c**	6	**T**		
7	**b**	7	**T**		
8	**a**	8	**F**		
9	**a**	9	**T**		
10	**b**	10	**F**		
11	**c**				
12	**a**				
13	**b**				
14	**a**				
15	**c**				

Large Cardamom

Questions:

I. **Choose the correct answer in the following:**

1. Large cardamom is also known as

a) Nepal Cardamom b) Bhutan cardamom c) Indian Cardamom

d) Bengal Cardamom

2. Fruits of large cardamom is almost the size of

a) Small cardamom b) Pepper c) Nutmeg d) Cinnamon

3. Scientific name of large cardamom

a) Amomum subulatum b)Elettaria cardamomum

c) Aframomum subulatum d) None of these

4. The mature plant height of large cardamom is

a) 1.5-3.0 m b) 3.0-4.0 m c) 4.0- 5 m d) 5-6.0 m

5. Capsules of large cardamom having the colour of

a) Greenish yellow b) Redish- brown c) Greenish white d) Yellowish green

II. Match the following :

Part -A		Part - B	
1	Ramsey	a	High yielding variety
2	ICRI Sikkim-1	b	Essential oil
3	Value added product	c	Large cardamom
4	Fruits	d	Cultivar of large cardamom
5	Greater cardamom	e	Eaten raw at sikkim

Answers

I

1	a
2	c
3	a
4	a
5	b

II

1	d
2	a
3	b
4	e
5	c

Lecture : 8 and 9.

GINGER

Scientific Name : *Zingiber officinale* Rosc

Family : *Zingiberaceae*

Indian Name : Sanskrit *Adraka* -- *Hindi - Adrak, English : Ginger, Kannada : Shunti*

Ginger, one of the oldest known spices, is esteemed for its aroma and pungency. Ginger of commerce constitutes both fresh and dry rhizome of *Zingiber officinale.*

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, Figi, 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.

Botany

Ginger, is a monocotyledon, with a slender, perennial herb-like habit, but is usually grown as an annual. It is 30-100 cm tall, With a robust branched rhizome borne horizontally near the surface of the soil, bearing leafy shoots close together. The fleshy, sympodial rhizome is hard, thick, somewhat laterally compressed, often palmately branched and usually pale yellow within. It is covered with small distichous roots in the top layers of the soil. The leafy shoots are annual, erect, about 50 cm tall and 5 mm in diameter. They are formed of long leaf sheaths and are glabrous, except for short hairs near the base of each leaf blade. The aerial pseudostems usually bear 8-12 distichous leaves. The lamina is thin, sub-sessile, linear, lanceolate, darkish green above, paler beneath, narrowed evenly to a slender tip, with an obtuse or rounded base.

The inflorescence arises directly from the root-stock, is spicate and 15-25 cm long. The scape is slender, with upper sheaths with or without short leafy tips. The spike is cylindrical and cone-like. The bracts are appressed, ovate or elliptic. They are green with pale sub-marginal bands and incurved, translucent margins. One flower is produced in the axil of each bract and is fragile and short-lived. The calyx is thin, tubular, and three-toothed. The corolla tube has three yellowish lobes. The labellum or lip, which probably corresponds to

three stamens, is nearly circular, with the side lobes free almost to the base, and coloured as the mid-lobe. The filament of the stamen in short and broad and the anther is cream-coloured. The stigma, protruding just below the apex of the appendage, has a circular optical aperture surrounded by stiff hairs. There are two slender free styloids. The inferior ovary is trilocular with several ovules per locule. The fruit, which is very seldom produced, is a thin-walled, three-valved capsule, with small, black, arillate seeds.

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 water-longging 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.

Improved Varieties developed from different research stations/institutes and released for cultivation are given below:

Variety! **Year of r ele** ase	**Pedigree! parentage** & plant type	**Institution /University**	Av. **yield** t/ha **(fresh)**	**Salient features**	Recommended state/regi on

Suprabha 1988	Clonal selection from Kunduli local	High Altitude Research OUA & T, Pottangi -764 Koraput (Dist), Orissa	16.6 (Pot!. yield 2280)	Plumpy rhizome, less fibre, wide adaptability, suitable for both early and late sowing, duration 229 days, 8.9% oleoresin, 4.4% crude fibre, 1.9% ess ential oil and 20.5% dry rec overy	Orissa and adjoining states
Suruchi 1990	Clonal selection from Kunduli local	-do-	11.6 (pot!. yield 23. 50)	Profuse till ering, bol d rhiz orne , suitabl e for rainfed / irrigated conditions duration 218 days, 10.9% oleoresin, 2.0% essential oil, 3.8% crude fibre, 23.5% dry recovery	Ori ssa, Central and South India
Surabhi 1991	Induced mutant of Rudrapur local	-do-	17.5 (Pot!. yield 23.00)	Plumpy rhizome, dark skinned yellow fl eshe d, suitable for both irrigatedlrainfed, duration 225 days, 10.2% Oleoresin, 2. 1% essential oil, 4.0% crude fibre, 23.5% dry recovery.	Orissa
V_3S_J-8	Sodium azide mutant	-do-	29.0	A mutant line moderately tolerant to diseases pests. Having an oleoresin content of 10.8%, essential oil 1.8%, crude fibre 3.2%, dry recovery '22.2%, suitable for green and dry ginger wide ecological adaptability, suitable for both hills and plains	Orissa, Andhra Pradesh, West Bengal, Madhya Pradesh, Uttar Pradesh, Bih ar
V_JE_S-2	An EMS mutant	-do-	32.9	A high yielding mutant with moderate tolerance to disease and pests. Contains 10.8% oleoresin, 1. 8% essenti al oil, 3.5% crude fibre, 21.4% dry rec overy, suitabl e for gre en ginger, late under rainfed condition in hills and plains	Orissa, Andhra Pradesh, West Bengal, Madhya Pradesh, Uttar Pradesh, Bihar
Himgiri 1996	Clonal selection from Himachal collection	Department of Vegetable YSPUH & F, Nauni, Sol an - 230, Himach al Pradesh	13. 5 (Pot yield 206t)	Best for green ginger, less susceptible to rhizome rot disease, suitable for rainfed condition, 4.29% oleoresin, 1.6% essential oil, 6.05% crude fibre, 20.2% dry recovery, 230 days duration	Himachal Pradesh
IISR Varada 1996	Selection from germplasm	Indian Institute of Spices Research, ICAR, Calicut-012, Kerala	22.6	High yielder, high quality bold low fibre content (3. 29% to 450%), essential oil 1.7%,6.7% oleoresin and 19.5% dry recovery, tolerant to diseases, maturity 200 days.	All overIndi a
IISR Rejatha 2004	Selection from germplasm	-do-	224	High yielder, plumpy and bold rhizome, 2.36% essential oil, 6.3% oleoresin, 4.0% crude fibre, 20.8% dry recovery, maturity 200 days.	Kerala and Kamataka
ISSR Mahima 2004	Sel ection from germplasm	-do-	23.2	High yielder, plumpy bold rhizomes, 1.72% essential oil, 4.5% oleoresin, 3.26% crude fibre, dry recovery 23.0%, maturity 200 days. The variety is resistant to nematodes *(M. incognito M.javamca)*	Keral a and adjoining States

Cultivation

Propagation

Ginger is propagated by rhizomes. The synseed technology protocols for rapid multiplication and also somatic embryogensis 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% orqano-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 a 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.

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.

Mulching

Mulching of beds with green leaves is an important and essential operation in ginger. Immediately after planting, beds are to be mulched with 15 tonnes per ha. of green leaves, which is repeated with 7.5 t 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.

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 land preparation. In addition, a fertiliser dose of 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 has to be applied after 60 days of the planting. 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.

In Kerala recommended fertilizer is 75 kg N, 50 kg P_2O_5 and 50 kg K_2O ha-1. The full dose of P and half dose of K are to be given as basal and ½ N applied 60 days after planting. Remaining half dose of n and half dose of k are to be applied 120 days after planting.

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') 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 maidan 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 is

intercropped 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 15-25 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 crystallised ginger.

Green ginger

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.

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, the two forms of processed, preserved ginger entering the market are:

1. Preserved ginger in sugar syrup
2. 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 characterised 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

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 delydrated 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.

REFERENCES:

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
5. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
6. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
11. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micropropagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
12. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
13. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
14. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.
15. Pruthi, J.S., 1989, Major Spices of India, Crop management Post-Harvest Technology, published by *Indian Council of Agricultural Research*, New Delhi.

OBJECTIVE TYPE QUESTIONS & ANSWERS

Questions:

I. choose the correct answers in the following:-

1. For propagation in Ginger, ideal rhizome weight should be….
   (a) 10-15 g (b) 60-70 g (c) 25-50 g (d) 80-100 g.

2. Origin of Ginger
   (a) South-East Asia (b) Australia (c) Mediterranean region (d) Guatemala.

3. Green ginger harvested at the age of
   (a) 3-4 months (b) 7-8 months (c) 5-6 months (d)9-10 months.

4. Exotic variety of Ginger is
   (a) Wynad (b) Rio de Janeiro (c) Manathodi (d) Karkala

5. Croppin of Duration of Ginger crop is
   (a) 5-6 months (b) 7-8 months (c) 10-12 months (d)3-4 months.

II. **State (tick) true or false:**

1. Ginger is a dicotyledon crop**.**
2. For getting bleached ginger, fresh rhizomes are soaked in copper for 6 hours.
3. India is the largest producer, consumer and exporter of Ginger.
4. Inflorescence of Ginger arises directly from the root stock is spicate.
5. Fruit production in ginger is very common.
6. IISR Mahima is a nematode resistant variety.
7. Irrigation is withheld 15-20 days before harvesting of the crop.
8. Green ginger forms the major bulk of international trade.
9. Ginger oleoresin (3.5-9 %) is obtained by the solvent extraction of ginger powder.
10. Calicut (NGK) Grade of Ginger has specification of Garbled, bleached and less than 20 mm rhizome size.

III. Match the following:

Part - A		Part – B	
1	Ginger Seed Technology Protocol	a	Malabar ginger type
2	Crystallised ginger	b	Lacks pungency
3	V_3S_1-8	c	3 fingers
4	Cochin ginger	d	Garbled, non bleached
5	Rhizome B grade	e	IISR, Calicut
6	Calicut (NGC)	f	Jamaica
7	Ginger oil	g	Sodium azide Mutant
8	Surabhi	h	Three valved capsule
9	Ginger fruit	i	Induced mutant of Rudrapur local
10	Local variety	j	Sugar syrup impregnation

Answers:

I main		II main		III main	
Sl No	Answers	Sl No	Answers	Sl No	Answers
1	c	1	F	1	e
2	a	2	F	2	j
3	c	3	T	3	g
4	b	4	T	4	a
5	b	5	F	5	c
		6	T	6	d
		7	T	7	b
		8	F	8	i
		9	T	9	h
		10	F	10	f

LECTURE 10

TURMERIC

Scientific Name : *Curcuma domestica Val : Syn. Curcuma longa*

Family : *Zingiberaceae*,

Turmeric is one of the important ancient sacred spice of Asian countries. Turmeric of commerce is the dried rhizome of *curcuma domestica* an herbaceous perennial plant. Curcumin the yellow colouring pigment present in rhizome, which has high medicinal value.

Turmeric (whole) is a unique, colourful and versatile natural plant product combining properties of a spice or flavourant, a colourant, a cosmetic and a drug useful against in a number of diseases. The largest quantity of turmeric is utilized as a food adjunct and colourant. It is also used as a dye. In Indian system of medicine turmeric occupies an important place, as an ingredient in the preparation of medicinal oils and ointments. It is a stomachic, carminative, tonic, blood purifier, vermicide and an antiseptic. It is also used in cosmetic preparations. Curcumin is an antioxidant and finds application in modern drugs for cancer therapy.

Apart from it is used as a spice, it has other uses. It is good source of yellow dye used for dyeing cotton, silk or wool without a mordant. 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. It is also used as protection against Charam' and considered as a symbol of good fortune. 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 Indian turmeric.

Botany:

Turmeric is an erect perennial herb, but is grown as an annual. The primary tuber at the base of the aerial stem is ellipsoidal, bearing many rhizomes, straight or a little curved, with secondary branches in two rows, which may have tertiary branches, the whole forming a dense clump. The rhizomes have a distinctive taste and smell. They are brownish and scaly outside and bright orange in colour inside. The leafy shoots are erect, less than 1 m in height, bearing 6-10 leaves with the leaf sheaths forming a pseudostem. The thin petiole is rather abruptly broadened from the sheath. The lamina is lanceolate, acuminate and thin, dark green above and pale green beneath, with ellucid dots. The inflorescence is a cylindrical spike, terminal on the leaf shoot, with the scape partly enclosed by the leaf sheaths. The bracts are adnate for less than half their length and are elliptic, lanceolate and acute. The upper sterile bracts are white or white streaked with green, pink-tipped in some cultivars, fading to light-green bracts below. The flowers are borne in cincinni of two in the axils of the bracts, opening one at a time, and are thin-textured and fugacious. The calyx is short, unequally toothed and split nearly half-way down one side. The corolla is tubular at the base, being the upper half-cup-shaped with three unequal lobes inserted on the edge of the cup lip; it is

whitish, thin and translucent with a hooded dorsal lobe. There are two lateral staminodes, elliptic-oblong, which are the hood of the dorsal petal. The filament of the stamen is short and broad, united to a versatile anther at about the middle of the parallel pollen sacs. The cylindrical stylodes are about 4 mm long. The ovary is inferior and trilocular with a slender style passing between the anther lobes and held by them. The fruits are few, if ever produced.

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 pseudostem 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).

Improved varieties developed from different research stations/institutes and released for cultivation are given below:

Variety and Year of release	Pedigree/ parentage & Plant type	Institution! U nfversity	Av. yield tlha (fresh)	Salient feature s
Co - 1 1983	Vegetative mutant by x-ray irradiation of Erode Lo cal	Dept. of Spices and Plantation Crops, HC & RI. TNAU, Coimbatore-641 003, Tamil Nadu	30.5 (Pot!. yield 35.0)	Bold and bright orange yellow rhizomes. curcumin essential oil 3.7%, dry recovery 19.5%, suitable for saline and alkaline areas. Crop duration 270 days. and taller (40-60 cm) with more no. of leaves (25 - 3.7 to 5.0
BSR-l 1986	Clonal selection from Erode Lo cal irradiated with x-rays	-do-	30.7 (Pot!. yield 39.6)	Bright yellow rhizome, curcumin 4.2%, oleoresin dry recovery 20.5%, crop duration 285 days, ofTamil Nadu
BSR-2	Induced mutant from Erode Lo cal	-do-	32.7	A high yielding short duration variety (245 days) resistant to scale insects

1994				
Krishna 1983	Clonal selection from Tekurp eta collecti on	M ah arash tr a Ag rl. U ni *v* ersi ty, Kasba, Digraj, Maharashtra-416 305	9.2 (Potl. yiel d 11.8)	Plumpy rhizomes, curcumin 2.8%, oleoresin 3.8%, recovery 16.4%, duration 240 days. Moderately
Sugandham 1984	Clonal selection from germplasm	Spices Research Station GAU, Jagudan-382701 Mehsana, Guiarat	15.0 (Pot!. yield 20.0)	Thick, round rhizomes with short internodes, 11.0%, essential oil 2.7%, dry recovery 23.3%, tolerant to pests & diseases
Roma 1988	Clonal selection from T. Sunder	High Altitude Research Station, OUA&T, Pottangi-764 039, Korapurt (Dis!,), Orissa	20.7 (Pot!. yield 40)	Suitable for both rainfed and irrigated condition, late season planting. Curcumin 6.1%, oleoresin dry recovery 31.0%. duration 250 days
Suroma 1989	Clonal selection from T. Sunder	-do-	20.0 (Pot!. yield 44.9)	Round and plumpy rhizome, field tolerance to l eaf rhizome scale, curcumin 6.1 %, oleoresin 13.1 %, recovery 26.0%, duration 253 days
Ranga 1992	Clonal selection from Rajpuri Lo cal	-do-	31.3 (Pot!. yield 37.1)	Bold and spindle shaped mother rhizome, suitable lying areas. Moderately resistant to leaf blotch and oleoresin 13.5%, essential oil 4.4% and dry days
Rasmi 1992	Clonal selection from Rajp uri Lo cal	-do-	31.3 (Pot!. yield 37.5)	Bold rhizomes, suitable for both rainfed and sown season, curcumin 6.4%, oleoresin i 3.4%, recovery 23.0%, duration 240 days
Rajendra Sonia 1989	Selection from Local germplasm	Dept .. of Hort., Tirhut College of Agriculture, RAU, Dholi -84 3121, Bihar	23.0 (Pot!. yield 420)	Bold and plumpy rhizome, grows widely under all Curcumin 8.4%, essential oil 5.0% and dry
Megha Turmeric 1996	Selection from Lakadong type	ICAR R.C. NEH Region, Shillong, Meghalaya	20.0 (Pot!. yield 27.5)	Suitable for North East hill and North West curcumin content 6.8% and dry recovery 16.37%,
Pant Peethabh 2001	Clonal sel ecti on from local types	Department of vegetable Science GB Pant University of Agriculture and Technolo gy, Pantnagar-263 145, Dist. Udam Singh Nagar, U ttaran ch al	20.0 (Potl. yield 29.0)	.Long attractive fingers, curcumin 7.5%, essential 1 8.5%, resi stant to rh izom e rot.

Suranjana (TCP-2) 2000	Clonal selection from local types of North Bengal	Uttar Bengal Krishi Viswa Vidyalaya, North Bengal Pundi bari (PO) :736 165, Dist. Cooch B ehar, West B enzal	Potl. yield (29.0)	Suitable for open and shaded conditions, sole or as well as high rain fall areas. Curcumin 5.7%, 4.1%, dry recovery 21.2%, duration 235 days, rhizome rot. Resistant to rhizome scales and borer.
Suguna 1991	Selection from germpl asm coll ection from Assam	Indi an Institute of Spices Research, rCAR, Calicut-673 012, Kerala	29.3 (Poll. yield 60.3)	Short duration type (190 days), curcumin 4.9%, 6.9% and dry recovery 20.4%, field tolerance to
Suvarna 1991	Sel ection from germplasm collection from Assam	-do-	17.4 (Poll. yield 43.5)	Bright orange coloured rhizome with slender tolerant to pest and diseases. Curcumin 4.3%, 7.0% and dry recovery 20.0%.
Sudharsana 1991	Sel ection from germplasm collection from Singhat, Manipur	-do-	28.8 (Poll. yield 54.9)	High yielding variety, short duration type (190 rhizome rot. Curcumin 5.3%, oleoresin *15.0"10,* recovery 20.6%.
IISR Prabha 1996	Open pollinated progeny selection	-do-	37.47	High yielding variety, curcumin content 6.5%, 6.5% and dri recovery 19.5%, croo duration 205
IISR Prathiba 1996	Open pollinated progeny selection	-do-	39.12	High quality line, 6.2% curcumin content with high 6.2% essential oil, 18.5% dry recovery, crop
IISR Alleppy Supreme 2004	A cl onal selection from Alleppy turmeric	-do-	35.45 5.58 (dry)	Shows tolerance to leaf blotch disease. Rhizomes *16.0"10* oleoresin, *19.0"/0* dry recovery, crop
IISR Kedaram 2004	Clonal selection from germplasm	-do-	34.5 5.28 (dry)	Tolerant to leaf blotch disease, Rhizomes contain oleoresin, maturity 210 days and 18.9% driage.
Kanthi 1996	Clonal selection from Mydukur variety of Andhra Pradesh	Dept. of Plantation Crops and Spices, College ofHort., KAU, Vellanikkara-680 656, Trichur, Keral a	37.65	Erect leafwith broad lamina, big mother rhizomes and closerinternodes. Medium duration. 8.25%, essential oil 5.15%, dry recovery 20.15%,
Sobha 1996	Clonal selection from local type	-do-	35.88	Mother rhizome big with medium bold and closer rhizomes is dark orange like Alleppey. More 19.38%, curcumin content (7.39%), oleoresin medium duration 240-270 days.
Sona 2002	Clonal selection from local germplasm	-do-	402 (dry)	Orange yellow rhizome, medium bold with no central zone of Kerala. Rhizome medium bold, Curcumin 7.12%, essential oil 4.4%, oleoresin me dium durati on. 240 -270 days.
Varna 2002	Clonal selection from local germplasm	-do-	4.16 (dry) (potl. yield 6.37)	Bright orange yellow rhizome, medium bold with fingers present. Suited to central zone of Keral a. curcumin 7.87%, essential oil 4.56%, oleoresin medium duration 240-270 days.

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.

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.

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 as the per package of practices 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_20_5 and half the dose of K_20 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_20.

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 is 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 arecnut 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 and processing

Depending upon variety, the crop becomes ready for harvest in 7-9 months after planting. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties after nine months. Harvesting at proper maturity results in the highest yield of cured turmeric. The land is ploughed and rhizomes are gathered by hand picking. Harvested rhizomes are cleaned off mud and other extraneous matter adhering to them. Yield/ per hectare comes to 20-25 t of green turmeric. High yielding

varieties yield up to 35 t/ha.

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

Dried turmeric has a poor appearance and a rough dull outer surface with scales and root bits. Appearance is improved by polishing outer surface by manual or mechanical rubbing. Turmeric is also polished in power operated drums. Yield of polished turmeric from the raw material varies from 15-25 %. *Colouring* Colour of processed turmeric influences price of produce. For an attractive product, turmeric powder may be prinkled during last phase of polishing.

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 :

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:

a. Finger turmeric, other than the Alleppey variety is sub-graded into 'Special' Good' and 'Fair.

b. Alleppey finger turmeric is sub-graded into 'Good' and 'Fair'.

c. 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 then 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.

Estimation of curcumin content

The curcumin content can be estimated adopting the method reported by Manjunath et al. (1991). For this, the cured rhizomes should be ground to a fine powder and 0.1 g of the powder should be extracted with 40 ml of distilled alcohol by refluxing over a water-cooled condenser for 2 1/2 hours. The extract should then be filtered into a 100 ml volumetric flask and made up to volume with alcohol. An aliquot of 5 ml should be transferred to a 100 ml volumetric flask and again the volume is made up. The absorbance of the solution can be measured at 425 nm with alcohol as the blank. The curcumin content in the sample can be calculated using the absorbance value of a standard solution of curcumin (0.00025 g/100 ml has an absorbance of 0.42), adopting the following formulae:

$$\text{Curcumin content} = \frac{0.00025 \times \text{absorbance of sample} \times 100 \times 100}{(\text{Per cent by weight})\text{absorbance of standard} \times \text{weight of sample} \times 5}$$

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 oleoresin

This is a highly viscous, orange-brown product containing 30-35% curcumin, 15-20% volatile oil and has a characteristic turmeric aroma. Turmeric oleoresin is prepared by the extraction of a good quality turmeric powder with solvents like acetone, alcohol or ethylene dichloride and subsequent desolventisation to meet the specifications. Since turmeric oleoresin is highly viscous, it is mixed with dilutents like propylene glycol or vegetable oil, to obtain a homogenous pourable product. Though such products have a lower colour value, they are more suitable for specific end uses. New-generation products based on turmeric oleoresin include spice emulsions/aqua resins and encapsulated water dispersible powders with advantages like dispersibility in oil or water, and ease of application. An established curcumin colourant has been prepared by spray drying turmeric oleoresin with an organic

acid, a buffer, a dispersant and an encapsulating material. Also, a powdered colouring agent, wherein curcumin is completed with gelatin in acetic acid, has been reported.

REFERENCES:

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
5. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
6. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
11. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micro-propagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
12. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
13. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
14. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.
15. Pruthi, J.S., 1989, Major Spices of india, Crop management Post-Harvest Technology, published by *Indian Council of Agricultural Research*, New Delhi.

TURMERIC

Questions:

I. **Choose the correct answer in the following:**

1. The yellow pigment present in rhizome of turmeric is

a)Curcumin b) Capsicin c) Capsanthin d) Charam

2. The largest producer and exporter of turmeric is

a) Sri Lanka b) Pakistan c) India d) Malaysia

3. The content of extraneous matter in Alleppey finger turmeric according to American Spice Trade Association is

a) < 0.5 % b) > 0.5 % c) 0.5 % d) 1.0 %

4. The value added product of turmeric is

a) Curcuminoids b) Dehydrated turmeric powder c) Oleoresin d) All of these

5. When curcumin comes in contact with alkali it turns

a) Blue b) Green c) Yellow d) Red

II. State whether the following sentences are True or False:

1. Turmeric prefers a warm and humid climate.
2. Turmeric is grown as a perennial crop.
3. Yield of polished turmeric from the raw material varies from 15-25 %.
4. Finger turmeric is graded as 'Special' and 'Fair'.
5. Use of growth regulators like kinetin, CCC and MH increase curcumin content of rhizomes.

Answers

I

1	a
2	c
3	a
4	d
5	d

II

1	True
2	False
3	True
4	False
5	True

LECTURE 11

CLOVE

Scientific Name : *Syzygium aromaticum Merrill and Perry. [Syn. Eugenia carryophyllus (Spregal)*
Family : *Myrtaceae*

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 'cloy' 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 sc. 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.

Botany :

The clove is an evergreen tree growing to a height of 7-15 m. The trunk is conical when young, later becoming roughly cylindrical. It begins to fork near the base, into two or three main erect branches. The smaller branches are semi-erect, the twigs are brittle, smooth and greyish-white in colour, and the whole head is bushy and dense. The leaves are simple, opposite, exstipulate, glabrous and aromatic owing to plenty of oil glands on the lower surface. The lamina is lanceolate or narrowly elliptic, bluntly acuminate at the apex, cuneate and bare. The new leaves appear in flushes and are bright pink. Later, the upper surface becomes glossy and dark green and wavy with recurved leaf margins. The hermaphrodite flowers are borne on a terminal, corymbose, trichotomous panicle. The inflorescence is shortly pedunculate, branched from the base and shorter than the leaves. The bracts and bracteoles are narrow, acute and fall quickly. The number of flowers varies from 3 to 50; a fleshy hypanthium is present, surrounded by the sepals. The hypanthium is green in the young bud, flushed pink at anthesis and turns deep red after the stamens fall. Above the sepals, there are four dome-shaped whitish petals. After fertilisation, the stamens and styles invariably fall. The lower part of the flower along with the calyx develops into a fleshy, dark, one-seeded drupe. The sepals are reduced to triangular projections and this is popularly

known as the 'mother of clove'. The stamens are numerous, the anthers are pale yellow, with a small, pale brown, inconspicuous connective gland. The style is very stout, swollen at the base, pale green and dotted with glands. The two-celled, multi-ovate, inferior ovary is embedded at the top of the hypanthium. The fruit (mother-of-clove) is usually a single-seeded drupe, but occasionally contains two seeds also.

Climate

Clove grows well under warm and humid climate. The 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-fertilising nature of clove. Although there are no named cultivars as such, in trade the differences of the spice are recognised 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 Zaniibar 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 recognised 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

Propagation

Clove is propagated through seed and vegetative means by soft wood cuttings and by buddings. 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 cowdung 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 cm^3 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.

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.

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

		kg
After 15 years	300:250:750 g	69.60:58.12:174.0 kg

The application of coconut meal, bonemeal or fish meal at 2-5 kg/ plant is beneficial. The manures can be applied in shallow trenches dug around the plant, normally about 1-11/2 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.

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 and yield

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.

The yield of cloves is found to vary from year to year. The average yield at Burliar 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

REFERENCES:

1. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
2. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
3. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
7. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
8. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
9. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
10. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

Questions:

I. **Underline the correct answer in the following:**

1. Part of commerce in clove is

a) Leaves b) Unopened flowers bud c) Fruit d) Aromatic bark

2. Major volatile oil present in clove is

a) Eugenol b) Glycol c) Gerenoil d) Caryoplyllene

3. Clove variety considered for best appearance.

a) Madagascar b) Zannibas c) Peuang d) Cochin

4. One kg of clove contains ..... number of dried cloves.

a) 5000-6000 b) 1000-1500 c) 11000-15000 d) 20000-25000

5. Quality of dried spice of clove depends on

a) Appearance b) Size c) Aromatic characteristics d) All of the above

II. Write whether the following sentences are True or False:

1. Distinct bud variant having bolder flower buds. Than the normal type is known as king clove.
2. Clove is propagated through seed which is called the mother's of clove.
3. Clove seeds has long viability.
4. The defective cloves in grading is known as khoker cloves.
5. On drying cloves retain about 2/3rds of their original fresh green weight.

Answers

I

1	b
2	a
3	c
4	c
5	d

II

1	True
2	True
3	False
4	True
5	True

CINNAMON

Scientific Name : *Cinnamomum verum* Presl. Syn *C.zeylanicum Bheme*

Family : *Lauraceae*

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 modifer. 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.* tama/a (Indian cassia). The other economically important species include C. cam phora, C. *oliven* and C. *malabaricum.*

Difference between Cinnamon bark and Cassia bark

Cinnamon bark	Cassia Bark
Bark is thin and smooth	Bark is coarce and thick
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 constituent 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.

Botany:

Cinnamon is a bushy, evergreen tree belonging to the family *Lauraceae*. It may reach a height of about 6-15 m, but in cultivation it is generally coppiced or cut back periodically. Its bark and leaves are strongly aromatic. The leaves are stiff, evergreen, with the petiole 1-2 cm long, grooved on the upper surface; the lamina is ovate or elliptic, 5-17 x 3-10 cm in area. It is strongly 3-veined from near the base, the lateral veins are 3/4 or more in length, it is reddish when young, and turns dark green above with paler veins and pale glaucous green beneath. The flowers are axillary borne in terminal panicles at the ends of twigs, the peduncle is creamy, white and 5-7 cm long. The individual flowers are very small, about 3 mm in diameter, with a foetid smell, each subtended by a small ovate hairy bract. It has 6, 9 sepals, companulate, pubescent, the stamens occur in 3 whorls with glands at the base, with hairy filaments and 4-celled anthers. The fruit is a fleshy berry, dark purple, 1-seeded, ovoid, 1.5-2 cm long with an enlarged calyx at the base. In Karnataka, the tree flowers in January and the fruits ripen 6 months later. The somatic chromosome number of C. *verum* is 2n=24.

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.

Improved varieties are Navashree and Nithyashree selections released from IISR, Calicut. Characteristic of these varieties given below:

S.No.	Character	Navashree (SI. 63)	Nithyashree (SI. 189)
1.	Regeneration capacity (shoots /plot of 4 plants)	25.45	18.90
2.	Fresh weight of bark (g)	488.95	511.15
3.	Dry weight of bark (g)	201.1	194.6
4.	Yield of bark/ha (kg)	55.56	54.16
5.	Recovery of bark (%)	40.6	30.7
6.	Bark oil (%)	2.70	2.70
7.	Yield of bark oil (l /ha)	1.50	1.46
8.	Bark oleoresin (%)	8.0	10.0
9.	Yield of oleoresin (kg/ha)	4.44	5.42
10.	Leaf oil (%)	2.80	3.00

Other improved varieties are

YCD-1

It is a cinnamon selection from Horticlutural 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 ©-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.

Cultivation

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.

Preparation of land and planting

The area selected for planting cinnamon is cleared and 50 cm^3 pits are dug at 2 m x 2 m or 3 m x 3 m or 3-5 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. 10-12 months old seedlings are used for planting, in each pit, 5 seedlings can be planted. 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 20 g N, 20 g P_20_5 and 25 g K_20 per seedling is recommended in the first year. The dosage is gradually increased to 50 kg FYM/ compost, 200 g N, 180 g P_20_5 and 200 g $_{1<20,}$ 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.

Pruning/Croppicing:

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. Preservation of moisture is very important for the subsequent operation, known as piping.

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 ones of 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.

: REFERENCES:

1. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
2. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
3. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
4. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
7. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

8. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
9. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
10. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
11. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.

CINNAMON

Questions:

I. **Write whether the following sentences are True or False:**

1. Cinnamon has Eugenol as main constituent in the leaf oil.
2. For propagation in cinnamon fruits are picked when the outer pulp begins to turn red.
3. About 4 kg of bark oil can be obtained from a hectare of cinnamon plantation.
4. Commercial cinnamon bark should be more than 0.5 cm thicker and thicker the bark better the grade.
5. Bark which cannot be taken out like tubes are called quillings and the scraped pieces called feathering.

II. Multiple choices questions:

1. Preservation of moisture in cinnamon bark is known as

a) Ripping b) Piping c) Sipping d) Nipping

2. IISR, Calicut released improved variety of cinnamon.

a) Divyshree b) Nithyashree c) Rathnashree d) Meghashree

3. Native of cinnamon is

a) Sri lanka b) China c) Pakistan d) Japan

4. Cinnamon belongs to family

a) Anacardiaceae b) Mysitiaceae c) Lauraceae d) Leguminaceae

5. Among the following, one is not the variety of cinnamon.

a) Sweet cinnamon b) Honey cinnamon c) Snake cinnamon d) Hot cinnamon.

Answers :

I

1 True
2 False

	3	True
	4	False
	5	True
II	1	b
	2	b
	3	a
	4	b
	5	d

LECTURE 12

NUTMEG

Scientific Name: *Myristica fragrans* Hout.,
Family: *Myristicaceae*
English name: Nutmeg
Indian name : *Jaiphal* (Hindi), *Jayikai* (Kannada),
Jathikka (Malayalam), *Jatiphala* (Sanskrit), *Jathikai* (Tamil), *Jajikai* (Telugu).

Nutmeg yields two types of spice viz., Nutmeg, it is the Kernel which is the hard and brown, enclosed in a thin brittle shell. (2) Aril (mace) is surrounding the shell which is scarlet in colour.

Nutmeg contains a volatile oil (6-16%) and mace contains a volatile oil (4-15%). The seed oil contains 4 % myristicin. The essential oil of mace is similar to nutmeg oil but it is fresher than the seed oil.

Mace is used as a culinary spice and largely as a flavouring agent. The husk is used for pickling, when the fruit is at a tender stage. The fresh husks of the ripe fruit can be used for making jelly. While separating the seeds from the testa and aril, some are broken and such seeds are rejected. Medicinally, nutmeg acts as a stimulant, astringent, aphrodisiac and carminative. The essential oil has uses in medicine, toilet soap, dental pastes, flavouring chewing gums, chewing tobacco, baked goods, cakes, cookies, puddings and pickles. The aromatic oil has a butter-like consistency and is orange in colour. The oil has been recommended for the treatment of inflammations of the bladder and urinary tract. Nutmeg butter is used in the manufacture of scented oils, ointments, perfumes and soaps, and as a flavouring agent in cooking and confectionery.

Origin and distribution:

Nutmeg is a native of the Moluccas Islands of Indonesia, the East Indies or Spice Islands. It is now grown in most tropical countries of the world, but is cultivated on a large

scale in the Malayan region. The British East India Company introduced this spice into India in 1800 AD. The countries producing nutmeg apart from Malaysia are Indonesia, Grenada, Sri Lanka, India, Tanzania, Mauritius, Reunion, Trinidad and Tobago and China In India, nutmeg is presently grown in Ernakulam, Cannanore, Kottayam, Thrissur, Idukki, Allepey, Mylapuram, Thiruvanathapuram, Palghat and Calicut districts of Kerala (3,502 ha), Dakshina Karnataka (110 ha) and also the Andaman and Nicobar Islands. Nutmeg is also grown near Courtallam in Tirunelveli district and around the Burliar zone of the eastern slopes of the Nilgiris, Anjarakandi near Coonoor of Tamil Nadu and Karnataka. The Araku valley in Andhra Pradesh and Wynad in Kerala are well suited for its cultivation.

Area and production:

In India the area under Nutmeg is 15,000 hectares with an annual production of 8,000 Mt. The productivity is 500 kg/ha. The total Indian production of Nutmeg and mace is 5,000 and 3,000 tonnes per year respectively.

Botany:

Nutmeg is an attractive, spreading, evergreen tree with dense foliage. Its somatic chromosome number is 2n=42. The trees are 10-20 m tall, sometimes reaching a height of 20 m or more. The branches are spreading with a dark gray bark. The leaves are shiny and oblong to oval in shape. The inflorescence appears in cymes. Each cyme has several branches bearing a number of flowers which hang down. The flowers are small, pale yellow and bell shaped and are slightly aromatic. The fruit is fleshy, globose in shape and lemon yellow to light brown in colour. Inside the fruit is the single, glossy brown seed with a brittle shell over which is the beautiful, brilliant, scarlet, net-like (reticulated) membrane or aril known as the mace, which is very fragile and aromatic. Nutmeg trees are dioecious in nature (the male and female flowers are borne on different trees). The monoecious condition is also reported to occur in aged trees at Burliar, in which case, double and triple nuts are produced and the yield from such trees is low. The quality of the spice is also poor.

The female and male trees can easily be identified by a trained eye. The male frees have erect branches and the leaves are generally smaller in size. The male trees are conspicuously less leafy than the female trees also; the shape of the tree is not as regular. The calcium oxalate content of the leaves is also taken as a criterion for the identification of sex in nutmeg.

Climate

Nutmeg thrives well in warm, humid conditions in locations with an annual rainfall of 150 cm to 250 cm and a temperature of 25-35°C. It grows well from sea level up to an

elevation of 1300 m. Partial shade appears to be beneficial in the early stages of growth.

Soil

Ideal soils for cultivation of nutmeg are river banks and hill valleys with clay loam, sandy loam and red laterite soils, which are rich in humus. Both dry climate and water-logged conditions are not good for nutmeg. It can grow well even in comparatively poor types of soils provided the soil is not sandy and not too wet or dry. A certain amount of iron in the soil is said to be beneficial to nutmeg trees.

Varieties

There are two basic types of nutmeg valued in the world trade. These are the West India and East India types. The West Indian variety is grown in the Islands of Grenada and Trinidad, while the East Indian nutmegs are highly aromatic and superior compared the West Indian variety. The fruits of the East Indian nutmeg are ovoid, approximately 2.25 to 2.75 cm long, 1.75 to 2.25 cm in diameter, and longitudinally wrinkled. The colour is greyish brown, with a furrowed network of dark brown-veins, in which the volatile oil is found.

The improved varieties of Nutmeg released are:

Konkan Sugandha

This variety was developed by Dr. Balasaheb Saw ant Konkan Krishi Vidyapeeth at Regional Fruit Research Station, Vengurle. This is the only hermaphrodite variety released. It yields 2.63 kg dry nuts (526 nuts) per tree at the age of 15 years. The nut size is 5g with 1.2 g mace.

Konkan Swad

This variety was developed by Regional Coconut Research Station, Bhatye, Ratnagiri, Maharashtra. It gives an average yield of 761.38 kg fruits/ tree. Seeds contain 39.8 % essential oil and mace 10.9 %.

IISR- Vishwasree

This is a high yeilding nutmeg selection from IISR Kozhikode. It gives an average yield of 3122 kg nut/ha (dry) and 480 kg mace (dry)/ha. This variety posesses 7.1 per cent oil in nut and mace, 13.0 per cent oleoresin in mace and 2.5 per cent oleoresin in nut. Butter content is 30.9 per cent in nut.

The other promising accessions under evaluation at IISR, Calicut, are: A 11/29, A 11/70, A9/20, A 9/22, A 9/25, A 9/79, A 9/86, A 4/12, A 4/22 and A 4/52. The IISR, Calicut, has a germplasm collection of 421 in nutmeg.

Cultivation

Propagation

Nutmeg can be propagated by seeds as well as vegetatively by patch-budding and epicotyl grafting. The percentage of success in the vegetative methods of propagation is

between 38-80%. The biotechnological method of in *vitro* synthesis of mace has been standardised.

Propagation by seeds

For raising seedlings, only well-matured, large seeds of uniform size, shape, light brown in colour with thick mace and low terpene content are collected. The seeds are dehusked and dried for a day before sowing. One kilogram contains about 200 small seeds or 90 big-sized seeds. The average number of small, medium and big seeds is 125 per kilogram. The seeds are collected from regular bearing and high-yielding trees, yielding more than 10,000 fruits per tree per year and having 30 g wet weight per fruit, 1 g wet weight of mace per fruit and 10 g wet weight of nuts per fruit. The seeds (7-9 g in weight) are sown three days after extraction and begin to germinate in four to six weeks. The sprouted seeds at the 2-leaf stage with a height of 15- 20 cm are transferred to polythene bags or when the seedlings are six months old, they are potted and allowed to remain in the pots for about 12 to 18 months prior to planting in the main field. For raising the seedlings, healthy fruits harvested during June-July are used. The seeds soon lose their viability and should be sown immediately. Regular care regarding watering is necessary for its good germination. The seedling progeny will give about 50% of each sex, which is very difficult to distinguish until the trees flower, i.e., 4-6 years after planting.

Vegetative Propagation

Nutmeg being a dioecious crop, proper ratio of female and male plants is to be maintained in the plantation. Vegetative propagation is the practical way to achieve this. Many vegetative propagation methods were standardised to develop a suitable method for relatively rapid multiplication. Vegetative propagation techniques like stem cuttings, air layering, approach grafting, epicotyl grafting, budding and top working were tried in nutmeg with varying degrees of success.

Epicotyle grafting: At Central Plantation Crops Research Institute (CPCRI), Kasaragod, Mathew and Joseph (1982) tried epicotyl grafting using M. beddomei as root stock and attained 48 per cent survival of grafts. Krishnamoorthy (1987) obtained 80 per cent successful grafts during the month of August when M. fragrans was used as the root stock.

At the Indian Institute of Spices Research, Kozhikode, epicotyl grafting was the most successful method. The technique of epicotyl grafting is given below:

1. Take 20 days old healthy sprout (root stock)
2. Select a good scion (of lead pencil thickness) from a high yielding female tree
3. Cut the top and make a vertical split to a length of 3-4 cm in the root stock
4. Make a wedge cut of 3-4 cm length in scion
5. Insert the scionin the slit of the root stock and tie it firmly with a polythene strip.
6. Transplant the grafted sprout to the polythene bag filled with the potting mixture. Grafted portion is covered with a polythene bag to ensure high humidity which helps in graft union
7. Remove the cover bag when new leaf emerges. Also remove the polythene strip. at the side of the grafting.

Maximum percentage of successful grafts (about 80%) could be obtained if grafting is carried out during August-September.

Epicoiul grafting : It was standardized at Konkan Krishi Vidya Peeth, Dapoli. Medium matured (4 months) and fully matured (6 months) scion sticks recorded higher success. It is essential to provide a cover of polybag on scion stick, especially in post rainy season. The location of scion stick did not influence the success of epicotyl grafting and September was the most favourable season for epicotyl grafting.

Harvesting season of nutmeg in Konkan region is confined from June to October. Hence availability of root stock particularly for epicotyl grafting is a limitation. Soft wood grafting method developed at Regional Coconut Research Station, Bhatye, Maharashtra provides scope for grafting nutmeg for prolonged period. May was the best month for soft wood graftirig with maximum success of 80 per cent. Retension of leaves on root stock did not influence the success of softwood grafting. Characteristic of scion stick and method of grafting were similar to that of epicotyl grafting.

Approach grafting: In India, successful approach grafting done on root stocks of M. *fragrans,* M. *malabarica* and *M.beddomei.* Those on M. beddomei and M. malabarica develop into low spreading trees whereas nutmeg seedlings generally develop into tall trees. Grafts come to flowering in 4-6 years of planting vs 6-8 years by the seedlings.

100 per cent success was observed when grafted on wild species of nutmeg, when erect branches of female nutmeg trees were used as the scion, flowering commenced in the second year after grafting. Trial on approach grafting at Dapoli showed that the approach grafts can be prepared throughout the year. High percentage of graft success was recorded on wild nutmeg root stocks *(M. malabarica,* 30-100 %) while on M. *fragrans,* it was 40-90 per cent. The mortality after separation of grafts was 30 per cent on M. *fragrans* and 50 per cent on M. malabarica. However, approach grafting is time consuming and a tedious method of grafting.

Budding: Forkert method of budding was tried in M. *fragrans* and M. *beddomei* and observed that percentage of success was very low (4%) in both the cases. They noted that maximum bud take was in May which coincided with the flushing season in nutmeg. Buds remained alive even after one year without sprouting. Forkert budding on sprouts of the topworked trees also gave only initial success, which failed to sprout even with physical and chemical treatments Commercial coverage through vegetative propagules is very much limited due to the unavailability of orthotropic shoots for use as scion. As a result, plagiotropic shoots are collected as the scion material. But such plants have a peculiar spreading habit resulting in squatty plants with stunted growth compared to seedlings of the same age. Therefore, the fruiting area is comparatively less resulting in low yield. Because of these factors, seeds continue to be the major propagating material even now.

Top Working: the sex of nutmeg tree can be identified only 7-8 years after planting, when they begin to flower. Generally, male and female trees are produced in 1:1 ratio. Since a single male tree is sufficient for every 20 female trees for pollination, the rest of the unproductive male trees can be made productive by converting them into female trees by top working.

Topping of male trees indicated that heading the trees above the first tire during August was the best with regard to sprout production and reducing the time for sprouting. Successful graft union by cleft grafting was obtained during March with scion shoots having mature leaf and full green stem and stock having two months growth.

The top working techniques adopted at Indian Institute of Spices Research (IISR), Kozhikode is as follows: Male trees are beheaded about 30 cm above the

ground level in May, the cut end is smeared with Bordeaux paste. ecapitated trees are irrigated regularly till the onset of monsoon. New shoots develop from the main trunk within 45-60 days. The newly emerged shoots are ready for grafting when they attain bout 20 cm length. A longitudinal cut of about 3 cm is made from the top downwards on the retained stock. This slit gives a 'v' shape when split opens. Orthotropic scions of the same thickness as that of the stock are collected in water from high yielding female trees of nutmeg on the same day of grafting. Scions with two leaves are used for grafting. The lower end of the scion is shaped into a wedge by removing the bark with a little wood from both the sides of the scion with a sharp knife. The scion is inserted into 'v' shaped slit of the stock and secured in place firmly with a 1.5 cm wide polythene strip. Grafted shoot is covered with a polythene cover to maintain humidity and to prevent the scion from drying. A temporary shelter is provided above the tree to prevent the harmful effects of rain or scorching sun. The olythene cover is removed after 30-45 days when perfect union takes place. Development of new buds from the grafted scion is an indication of perfect union. After successful union, all other shoots are removed from the main trunk and Bordeaux paste is applied on the cut surface. Overhead shade can be removed after ensuring successful union of the graft. If the graft fail, regrafting can be done on either the same shoot or on a different shoot. This technique assures cent per cent success. Top working can be used for conversion of unproductive male to productive female trees. The top worked trees yield from the 3rd year onwards. Aftercare of top worked trees include removal of new shoots that sprout from the main trunk and regular management practices especially irrigation.

In situ budding: In situ budding is now the most popular method followed by farmers of Kerala to solve the two major problems that restrict large scale cultivation of nutmeg namely doiecy and long juvenile phase.

Budding can be done on plants within 2-5 years of planting. Orthotropic scion shoots from elite mother trees are budded on seedlings two years after planting in the main field. The root stock and scion should be at the bark slipping stage. Budding is done just above the first whorl of lower leaves.

Studies at Kerala Agricultural University proved that in situ budding on hard trunk was the most successful. Forkert method with brown bud wood having fallen leaves and the buds inserted by leaving space on all four sides gave maximum success. In order to achieve a quicker bud burst, stumping the plant two months after budding was the most effective. Budding on hard trunk could be done with maximum success

in three year old plants and July was found the best season.

Maximum success obtained with patch budding on M. *fragrans* and forkert method on M. *beddomei.* August was the best season for in situ budding and July for budding in polybag plants. Partial shade was ideal for better bud take than the mist chamber conditions. Stumping the root stock above bud union retaining the whorl of lower leaves gave better sprouting and late survival.

Land preparation and planting

The planting is done at the beginning of the rainy season. A spacing of 8 m x 8 m or 9 m x 9 m is required for nutmeg plantations. Pits of about 0.75 m^3 to 0.90 m^3 are dug and filled with organic manure and soil about 15 days prior to planting.

The plants should be shaded by planting banana or glyricidia to protect them from sun scorching in the early stages. Permanent shade trees should be planted when the site is on hilly slopes and nutmeg is grown as a monocrop. Nutmeg can also be grown as a mixed crop in the old coconut and arecanut gardens, where the light shade conditions are suitable. One nutmeg can be planted at the centre of 4 coconut plants; while in arecanut, nutmeg can be planted at every third row so that within the square formed by 4 nutmeg plants, there are 9 arecanut seedlings.

Ten per cent of males may be retained for pollination and the remaining male trees may be either removed or converted to females by top working.

As an intercrop in coconut plantations, nutmeg is planted in between two rows of coconut so as to accommodate 125-150 plants per ha. In the Andaman and Nicobar islands, combinations of coconut or arecanut + nutmeg + robusta coffee + or forest treese- nutmeg + robusta coffee + pepper were successful. Spectacular yield increase of coconut palm and thereby total yield by intercropping nutmeg in coconut plantation.

Manures and Fertilizers:

Farm Yard Manure is applied at 10 kg per pit and gradually increased to 50 kg per plant for a 15 year old tree. The fertilizer doses vary with the age. In the first year after planting, a dose of 20 g N, 18 g P_20_5 and 50 g K_20 is given per plant. The dosage for the second year is 40 g, 36 g and 100 g; and after five years it is 100 g, 90 g and 25 g; and after fifteen years a dose of 500 g, 250 g and 1000 g of N: P_20_5 and K_20, respectively, are applied. The manure may be applied in shallow trenches dug sufficiently far away from the base of the tree. The manures and fertilisers are applied twice a year once in May-June and then again in September-October, depending upon the availability of moisture or rainfall.

Irrigation and inter-culture

Regular weeding and irrigation are required for its good growth, early bearing and higher yield. Irrigation in summer months is a must in dry areas. For 4-year-old plants, 20 litres of water per plant thrice a week is given and the quantity increases at the later stages of growth. Gramaxone can be used for chemical weed control. In lighter soils, the plant basins are mulched with heavy mulches of organic matter.

Harvesting and yield

The female nutmeg tree starts fruiting from the sixth year onwards; but, the peak harvesting period is reached after 15 or 20 years and continues for 40 years or more. The fruits are ready for harvest in about 6-9 months after flowering. The flowering and harvesting continue throughout the year, but, June-August or December—May are the peak periods.

The fruits are ripe and ready for harvesting when the pericarp splits open. The harvesting is done by using a bill hook. The fruits are split open, the outer fleshy portion is removed, and the mace is manually separated from the nut. Then, the nut and mace are dried separately in the sun in a drying yard. The mace should be dried for 10-15 days and the nuts for 4-8 weeks till the kernel rattles within the shell. The scarlet-coloured mace gradually becomes yellowish-brown and brittle when the drying is completed. The fresh pericarp can be used for making pickles, jams and jellies.

Trees of 15 years of age and above will yield about 1000-2000 or more fruits and large trees, which are over 30 years of age, may yield about 3000-10000 fruits per year. The yield per hectare may vary from 1000-1500 kg of nutmeg and 200-500 kg of mace per annum. The mace to nutmeg ratio is about 3:20 on a dry weight basis. Generally, if the fruit weight is 60 g, 6-7 g nutmeg and 3-4 g mace can be recovered. The rest will be the pericarp. For every 100 kg of nutmeg, a tree produces only 4 kg of mace.

Grading

The dried nutmegs are graded by hand according to their weight, shape and colour. After grading, the nutmegs are fumigated with methyl bromide to protect them from storage pests.

The following classifications have been made in nutmeg trade.

1. Whole and sound nutmeg
   This is used in spice trade as: (a) large (b) medium and (c) small
2. Sound shrivels
   These are employed for grading, but are usually too expensive for oil distillation.
3. Rejections
   Considerably low-priced, this grade can be used for the distillation of oil.
4. Broken and warmy

This grade is also suitable for oil distillation. The grades of mace are as follows;

a) Banda *Mace* is considered to be the finest It has a bright orange colour and a fine aroma
b) *Jaye Estate Mace* is golden yellow, interspersed with brilliant crimson streaks.
c) *Siauw Mace* is of a lighter colour than Banda *mace* and contains less volatile oil
d) *West Indian Mace*, often regarded as the fourth grade of East Indian mace, is derived from M. *argentea.* It contains less volatile oil with an undesirable turpentine-like aroma. It is unsuitable for distillation purposes. `Banda' and Penan maces are considered to be superior in quality by the trad the world over. Mace is available in the market as 'whole', 'broken' or 'ground'.

Adulterants

Nutmegs are sometimes adulterated with 'false' nutmegs (M. ma/abarica) or 'Bombay nutmegs', which are odourless and tasteless. The oil is sometimes adulterated by the addition of turpentine oil or pinene.

Mace is also sometimes adulterated with 'Wild Mace' (M. malabarica), which is of inferior quality.

Extraction of oil

The essential oil is extracted from the seed, mace, leaves and also the bark by steam distillation. For oil distillation, the economically viable and accepted materials are the rejections from spice trade. The oil yield ranges from 6 to 16% in nutmeg, 4 to 15% in mace, 0.14% in the bark and 0.4 to 0.6% in the leaves.

Nutmeg contains 25-40% fat, which can also be recovered using solvents or by mechanical pressing. It is highly aromatic and its major constituent is trymyristicin. The oleoresin is extracted with solvents. It may also have butter; about 7-16% nutmeg oil is found in it. Aromatic ethers, myristicin and elemicin are present in the oil and oleoresin.

Value-added products

The value-added products are nutmeg oil, mace oil, nutmeg oleoresin, mace oleoresin, myristicin, nutmeg butter, the volatile oil of the bark and flowers.

REFERENCES:

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadaa, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
11. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
12. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.
13. Parthasarathy, V.A. and Rajeev, P., 2010, Major Spices-Production and Processing, published by *Indian Institute of Spices Research*, Calicut.

NUTMEG

Questions:

I. **Under line the correct answer in the following:**

1. Nutmeg oil contains.

   a) Myristicin b) Eugenol c) Linalool d) Cryophyllea

2. Chromosome number of nutmeg is

   a) 2n=32 b) 2n=42 c) 2n=18 d) 2n=24

3. The mace to nutmeg ratio on dry weight basis

   a) 4:20 b)1:25 c) 8:60 d) 3:20

4. Nutmeg is propagated through

   a) Seeds b) Epicotyl grafting c) Patch budding d) All of these

5. Successful approach grafting done on root stocks of

   a) M. Fragrans b) M. omalabarica c) M. Beddomei d) All of these

II. Write whether the following sentences are True or False:

1. Nutmeg is monoecious in nature.
2. East Indian nutmegs are highly aromatic and superior compared to west Indian variety.
3. The fruits are ripe and ready for harvesting the pericarp splits open.
4. Nutmegs are adulterated with Bombay nutmegs which are odourlees and tasteless.
5. For every 100 kg of nutmeg, a tree produces only 4 kg of mace.

Answers:

I

1	a
2	b
3	d
4	d
5	d

II

1	False
2	True
3	True
4	True
5	True

ALLSPICE

Scientific Name: *Pimento dioica* (Linn.) Merr.Syn. *P.officinalis* Lindl, *Eugenia pimenta* DC,
Family: *Myrtaceae*
English name: Allspice, Pimenta, Pimento, Jamaica Pepper
Indian name: *Gandamenasu, Sarwasambaru* (Kannada), *Kappalmulaku* (Malayalam), *Kattukkaruve* (Tamil)



All spice is aromatic minor spice plant, the spice is called `pimenta'. The term pimenta had its origin in the initial incorrect belief of the early Spanish exporters who thought these berries were similar to pepper. Then came the English expression 'Jamaica pepper' and the German 'Nalkenpfeffer'. It is now officially recognized as `pimenta'. The allspice or 'pimento' of commerce is the dried immature fruit. The name 'Allspice' came from the fact that the spice is said to possess the characteristic flavour and aroma of cloves, nutmeg and cinnamon all combined in this one spice. Allspice is available both in whole or ground form. The characteristic odour of allspice is due to the presence of an essential oil (3.3-.45%), concentrated mainly in the pericarp.

The berries are used as a condiment and flavouring agent in ketchups, soups, sauces, pickles, canned meats, sausages, gravies, relishes, fish dishes, pies, puddings, preservatives, etc. They are used as a flavouring ingredient for wines and as a perfume in soap making. It is an important ingredient of whole mixed pickling spice and spice mixtures, *viz.*, curry powders, mincemeat spice, poultry dressing, frankfurter and hamburger, etc.

Allspice is used as an aromatic stimulant in digestive troubles. The powdered fruit is used in flatulence, dyspepsia and diarrhoea. Earlier, it was used in medicine as an adjuvant to tonics and puratives. It is considered to be carminative. It is an anodyne against rheumatism and neuralgia. Pimenta berry oil is used for flavouring condiments and food products and in perfumery, soap and pharmaceutical preparations.

Origin and distribution

Allspice is indigenous to West Indies and tropical Central America and grows semi-wild in Jamaica (West Indies), which is the major producer. It is also reported to occur in Southern Mexico, Honduras, Guatemala, Cuba and Costa Rica. In India, allspice is cultivated in West Bengal, Bihar and Orissa. The cultivation is slowly increasing in Kerala, Karnataka and Tamil Nadu. It is found to grow well and fruits heavily in Bangalore. Its cultivation has been recommended in the hilly districts of Karnataka along the river valleys.

Area and Production:

The area under this crop is less and statistics about the crop is also not available.

Botany:

Allspice is a small, medium-sized evergreen tree which grows upto a height of 8 to 10 m. The flowers are small and whitish in colour with a peculiar aroma. They are present in groups of cymes. They are structurally hermaphrodite, but functionally dioecious and are scientifically called *Polygamo dioecious'*. Those trees which bear no fruit are male trees wherein the flower will have above 100 stamens, while the flowers bearing female trees have around 50 stamens. The receptacle has four cream-coloured calyx lobes, spreading at the anthesis and persistent in the fruit. There are four petals, which are whitish and quickly decidous. The style is white with a yellow stigma. In females the style is slightly shorter and the stigma longer than in the barren trees. The ovary is inferior and 2-celled, usually with 1 ovule in each cell. The plants flower during March-June and the fruit, which is a berry (4-7 mm in diameter), matures 3-4 months later. For spice purposes, it is picked when it is fully developed, but still green. The fruit has two kidney-shaped seeds. The male trees flower early. These plants normally do not bear fruit in the plains.

Climate:

Pimenta grows from sea level to an altitude of 1000 m above MSL; however, it also grows well below 300 m. An annual rainfall of 100 to 200 cm or more with a mean monthly temperature upto 27°C are ideal. The performance of allspice in the plains is poor and fruiting is not observed.

Soil:

The plant grows in a wide range of soils including poor soils with good drainage. It is not suited to red soils with inadequate moisture. Lateritic soils with rich in humus is good for the crop. The pH ranges between 5.5-6.5 is ideal.

Varieties

There are no named varieties but there are few local varieties available in the Nagarcoil area, Kaliar and Burliar. IISR, Calicut has a germplasm collection of 137 indigenous types. The dwarf and semi dwarf plants are identified from the germplasam existing in the station and utilized in crop improvement programme.

Cultivation

Propagation

Seed propagation is the common method of propagation of allspice. To obtain the seeds, the ripe fruits are collected from high yielding and regular bearing trees. The seeds are extracted after soaking the fruits overnight in water, rubbing in a sieve and washing them with clean water. The seeds are dried in the shade. The seeds should be sown immediately or else germination is reduced. The seeds are sown in nursery beds, boxes, pots, basins or polyethylene bags (30 x 15 cm). Beds of 1.2 m width are prepared by using light soil and incorporating organic matter or a mixture of sand and coir dust or coir dust alone. After sowing, the nursery beds are mulched to hasten germination. Dried leaves, straw, paper and damp sacks are used as mulch. Watering is done using a fine spray. Germination takes place between 9 and 10 days or sometimes 15 days after sowing.

Vegetative propagation by bottle grafting, budding, approach grafting, air layering and top working are also possible in this crop. Propagation by micro-propagation is also reported. Shoot tip cultures of allspice could be established and activated to grow. Callus cultures from leaf as well as shoot explants could also be established. January was the best month for air layering which recorded cent percent success. Leafy softwood cuttings treated with IBA 1000-1200 ppm enhance the rooting percentage.

Land preparation and Planting:

The land selected for planting should be cleared of wild vegetation. In slopy areas contour planting is suggested. Pits of 60 cm^3 are dug at the recommended spacing and they are filled with well rotten FYM or compost and top soil.

Six to ten-month-old seedlings, 25-30 cm in height are ideal for field planting. The seedlings are planted at a spacing of 6m x 6m. If the soil is poor in fertility, closer spacing is suggested. To avoid losses, instead of one seedling, three are planted in each pit. When

grafted plants are used (278/ha), it is suggested to plant one per pit. To ensure sufficient 'males' as pollinators, it is necessary to plant female and male in the ratio of 8:1. Care should be taken at the young stages by providing shade and regular irrigation to reduce casualties in the main field. Allspice can be grown as an intercrop in arecanut, coconut gardens and coffee estates.

Manures and fertilizers:

Very little work has been done about use of manures and fertilizers, however, the tentative, fertiliser schedule per plant is the application of 10 kg compost along with 20:18:50 g of N, P_20_5 and K_20 during the first year, and 20 kg compost with 40:36:100 g of N, P_20_5 and K_20 during the second year. The dose is gradually increased to 50 kg compost and 300:250:750 g of N, P_20_5 and K_20 per tree upto 15 years after planting. In some areas it is recommended to apply 80 kg FYM and 300:250:700 of NPK per plant from the 151n year onwards. The fertilizer is applied in two splits, one in May-June and another in September-October.

Irrigation

The plants are watered during the dry months in the early stages of growth, upto 2-3 years after planting.

Weeding

As the crop is widely spaced, weed problems are common, especially in the early stages. The base of plants should always be kept clean by regular weeding and mulching. Weeds are controlled chemically by using a herbicide like Gramaxone (Paraquat).

Regulation of flowering and fruit set

Generally, allspice is a shy bearer of flowers/fruits. In order to enhance the seed set, the tree basins should be drenched with Cultar (Paclobatrazol) at low concentrations. The plants are reported to show a positive response to flowering and fruit setting.

Use of growth regulators:

Allspice generally does not set seed under all agro-climatic conditions. Combined application of Indole Acetic Acid (IAA) and Benzyl adenine (BAP) (50:5) results not only in fruit setting but also in producing large-sized fruits.

Harvesting and Processing:

Vegetatively propagated plants start flowering in three years and seedlings in 5-6 years under good management. The male trees flower early compared to the female ones

and the usual flowering time in India is during March to June. The tree takes 20-25 years to come to the full bearing stage and continues upto a good age. The fruits are ready for harvest after 3-4 months of flowering. The berries grow in clusters, and are best used as the spice when they are green, fully matured but not ripe. The unripe berry is more spicy and somewhat peppery in taste. They are manually gathered by climbing up the tree on a ladder. After harvesting, the ripe berries are separated from the green ones.

The berries are spread out in the sun and turned over with a wooden rake, so that they dry uniformly. Drying takes three to twelve days. A good dry wind accelerates the drying process. The end product should be bright brown in colour. The completion of drying is confirmed by sharp, dry and crisp rattling sounds when a handful is shaken close to the ear. Then the berries are cleaned by winnowing and stored after removing any dust. A well-grown tree yields 20-25 kg of dry berries per year. Yields as high as 50 to 60 kg of dry berries have also been reported. The berries are light and about 14,000 berries weigh 1 kg.

Pimento should be stored in gunny bags lined with polyethylene in covered premises, well protected from the sun, rain and excessive heat.

Grades/types

Pimento is marketed as whole or ground pimento. There are four major grades/types of pimento that are traded. They are, Mexican, Guatemala, Honduras and Jamican pimenta. Jamaican pimenta has the best appearance, aroma, flavour and volatile oil content (4.0-4.5%). The dried berries range in size from 6.5 to 9.5 mm in diameter and there are 13 to 14 berries per gram.

Value-added products

Pimenta berry oil

The essential oil (3.3 to 4.3%0) obtained by steam distillation of the crushed dried berries is known as pimenta berry oil. The oil has resin, protein, pentosans, starch, traces of alkaloids, pigments and minerals. It is yellow to yellowish-red in colour. It darkens with age and possesses the characteristic colour and warm spicy and sweet flavour of allspice. It contains eugenol (65-80%), methyl eugenol (8%), beta-caryophyllene (4.2%), humulene

(2.7%) and cineole (2.3%).

Pimenta leaf oil

Steam distillation of dried pimenta leaves yields 1.8-3.8% of an oil, which is the pimenta leaf oil. The leaf oil contains eugenol as its main component (58-62%), it also contains myrcene (14-17%) and 1, 8- cineole (6.6-8.4%) but has an inferior odour and flavour to that of the berry oil. The leaves also contain tannin which may be used for tanning purposes.

Pimenta oleoresin

The berries are processed on a small scale in some of the importing countries for the manufacture of oleoresin.

Pimenta bark and wood

Pimenta bark also contains tannin and a small quantity of essential oil. The wood from the tree trunk is dark to light salmon pink in colour with a very firm, hard, close texture and a smooth surface. The wood is used for making sticks, umbrella handles and cart shafts.

REFERENCES:

1. Chadha, K.L., Retrinam, P 2010 plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
2. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
3. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
4. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
5. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
6. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
7. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
8. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
9. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

ALLSPICE

Questions:

I. **Under line the correct answer in the following:**

1. Allspice ovary is inferior and

a) 3 celled b) 2 celled c) 4 celled d) One celled

2. To ensure sufficient pollination in Allspice female to male ratio planting is

a) 10:2 b) 6:1 c) 8:1 d) 9:3

3. Allspice tree comes to full bearing stage in

a) 20-25 years b)10-15 years c) 8-10 years d) 4-5 years

4. Scientific name of Allspice is

a) *Pimento dioica* b) *Pimento allspicae* c) *Syzgium dioica* d) *Eugenia officinalis*

5. Common method of propagation of allspice

a) Grafting b) Air layering c) Seeds d) Budding

II. Write whether the following sentences are True or False:

1. Allspice posses characteristic flavour and aroma of cloves, nutmeg and fennel
2. Allspice is structurally hermaphrodite, but, functionally dioecious.
3. Allspice generally best seed under all agro-climatic conditions.
4. Unique berry of allepice is more spicy and peppy in taste.
5. Jamaican pimento has best appearance, aroma flavour and volatile oil content.

Answers

I

1 b
2 c
3 a
4 a
5 c

II 1 False
2 True
3 False
4 True
5 True

LECTURE 13 & 14

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. All parts of the plant are indispensable food adjuncts in Indian cookery. The young plants are used as a spice in the preparation of chutneys, sausages, curries and soups for flavouring. The dried fruits are an important ingredient of curry powder, sausages and pickling spices. In the USA and Europe it is used for flavouring spirits and gin. In food industries, coriander is one of the important ingredients in the manufacture of bakery products, imitation flavours, pork, meat, fish and salads, soda and syrup, gelatin, dessert, candy, preserves, chocolates and liquors. The essential oil of coriander seeds is a valuable ingredient in perfumery industries.

Coriander is also used as a carminative and flavouring agent and to correct the griping qualities of other medicines. A herbal tea of coriander with milk cures bleeding of piles. The fruit is antispasmodic, diuretic, aphrodisiac, refrigerant and stimulant. A decoction of the dried fruit is given for treating flatulence and colic. It is also reported to lessen the intoxicating effects of spirituous liquors. 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, Gujarath, Andhra Pradesh, Bihar, Karnataka, Maharastra, Madhya Pradesh, West Bengal and Tamilnadu. In Karnataka, the crop is cultivated in the districts of Darwar, Bijapur, Bagalkot, Chithradurga, Chikkamagalore and Belgaum.

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.

Botany:

The plant is a smooth, erect annual herb, 30-90 cm high, with conspicuously enlarged nodes and hollow internodes. The stems are vertically ridged. The leaves are pinnately compound and often decompound. The lower leaves are broad with serrately-lobed margins. The upper leaves are finely cut with linear lobes. The petiole is often swollen, even, hollow at the base and sheathing the stem. The leaf arrangement is alternate. The plant comes to the flowering stage in about 45-60 days after sowing. The flowers are small, white or pinkish in compound terminal umbels. There are 5 sepals, 5 petals, 5 stamens and 2 carpels which are free with an epigynous ovary. The fruit is a schizocarp, globular, yellow in colour with brown ribs. The size of the seed is about 3 mm in diameter and ripe seeds are aromatic. At dehiscence, the 2 carpels called mericarps separate, each containing a single seed with a copious endosperm and a minute embryo.

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 and in Karnataka from May to August and from October to January.

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 is

applied. 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 under

limited 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 11.0 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 14.5 q/ha.

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, straw-coloured 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 P_2 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 produces

an 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.

Cultivation

Propagation

Coriander is propagated by seed. Before sowing the fruits are rubbed until the two mesocarps are separated and then 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 is 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 tonnes of well rotten FYM and NPK @ 60-9-; 15-50 and 15-30 kg/ha respectively are recommended for

Indian conditions.

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 and

stacked 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 major types of the spice 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 and anethole 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.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345.
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

10. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.

CORIANDER

Questions:

I. **Under line the correct answer in the following:**

1. The essential oil content of the coriander seed is about.

   a) 0.1 to 0.7 % b) 0.5 to 0.9 % c) 1.0 to 1.2 % d) 0.5 to 0.75 %

2. The scientific name of coriander is

   a) Alium coriandrum b) Coriandrum sativum c) Sativum coriandrum

   d) None of these

3. The active principle of the coriander is

   a) Capcicin b) Allicin c) Anithol d) Linolool

4. Spacing followed in coriander is

   a) 10-20 x 5 cm b) 20-30 x 10 cm c) 15-20 x 10 cm d) None of these

5. Per hectare seed rate requirement in coriander for irrigated crop is

   a) 10-15 kg b) 5-10 kg c) 10-20 kg d) 20-25 kg

II. . Match the following:

Part-A		Part-B	
i	Coriander seed treatment	a	Co 1
ii	Weedicide for coriander	b	UD 20
iii	Coriander variety for seed purpose	c	1.5 – 3 mm
iv	Micro carpum	d	Agrosan – GN
v	Coriander variety for dual purpose	e	Pendimethalin

Answers

I

1 a
2 b
3 d
4 b
5 a

II 1 d
2 e
3 b
4 c
5 a

FENNEL

Scientific Name : *Foeniculum vulgare* Miller
Family : *Apiaceae*
English name : Fennel
Indian name : *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 *(Foeniculum vulgare* Miller), commonly known as *Saunf* or *Badi saunf. It* is 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.

Botany:

Fennel is a annual, biennials or perennial aromatic herb. The biennials and perennials have firm and round, greenish-blue, finely straighted stem, 150-200 cm high. There are 2-4 leaves which are pinnate, the segment is always very narrow and often filiform. The flowers in large numbers are found in the second year of growth; these are small and yellow flowers (June-September). The flowers are borned in flat topped umbrella like clusters (umbel). The fruits at first are bluish, then become brownish-gray. All the parts of the plant are aromatic. Different races of fennel exist with fruits that are sweet or bitter or acidic in taste. The fruits are oblong, cylindrical, 6-7 mm in length, slightly curved, greenish or yellowish-brown in colour, 5-ridged, with prominent furrows with oil glands. The fruits yield a volatile oil 0.7– 6 %. The chief constituent of which is anethole (50-70 %). Fennel seeds also contain 9-13 % fixed oil.

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.

Season

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

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 Gujarath 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.

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.

Other released varieties are:

Gujarat Fennel 2, Hissar Swarup, Azad Sanuf 1, Pant Madhurika and Rajendra Sourabha.

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 11/2 — 2 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.

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 P_20_5 and 21 kg $K._20$ /ha is recommended. The application of 30-100 kg of N, 25-60 kg P_20_5 and25-90 kg of $1\{_20$ 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 as a top-dressing when the crop is just before flowering. 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

Fennel is most vulnerable to frost damage at the flowering and early seed-formation stages. The frost damage can be minimised 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.

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 recognized in commerce: (i) Sweet fennel oil from the fruits of var., *dulce*, and (ii) Bitter fennel oil from the fruits of var., *vulgare.*

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.

6. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
7. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
8. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
9. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micro-propagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
10. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
11. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

FENNEL

Questions:

I. **Choose the correct answer in the following:**

1. The major constituent of the fennel oil is

   a) Methyle b) Anethole c) Aectol d) None of these

2. The percentage of protein present in fennel seed is

   a) 10-12 % b) 15-20 % c) 14-22 % d) 5-10 %

3. The frost damage in fennel crop can be minimised by spraying.

   a) Sulphuric acid b) Acetic acid c) Hydrochloric acid d) None of these

4. The per hectare seed yield in fennel ranges from

   a) 5-10 quintals b) 10-15 quintals c) 15-20 quintals d) 20-25 quintals

5. Which crop is found to be remunerative as intercrop with fennel.

   a) Radish b) Tomato c) Cabbage d) Cauliflower

II. Write whether the following sentences are True or False:

1. Fennel oil is used as germicide.
2. Fennel crop is best suited to South Indian weather.
3. PF-35 is a fennel seed variety developed by Tamilnadu Agricultural University.
4. The fennel seeds from Lucknow are higher priced than those from other areas.
5. The oil obtained from fennel fruit is white in colour.

Answers

I

1	b
2	c
3	a
4	d
5	a

II

1	True
2	False
3	False
4	True
5	False

FENUGREEK

Scientific Name : *Trigonella foenum-graecum L.*
Family : *Fabaceae*
English name: Fenugreek, Greekhayes
Indian name: *Methi*, *Methe* (Hindi, Sanskrit), *Menthya* (Kannada), *Ventayan*, *Uluva (Malayalam)*, *Vendayam*, *Venthiyam* (Tamil), *Mentulu*, *Menthulu* (Telugu).

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%).

As a spice, fenugreek adds to the nutritive value and flavour of foods. 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. Fenugreek is a popular ingredient of bread known to Arabs as 'hubla' in Egypt and Ethiopia. In Gujarat and Maharashtra, fenugreek flour is used in the preparation of chapathi.

Medicinally, the leaves are refrigerant and aperient and are given internally for vitiated conditions of *pitta.* The seeds are used for colic, flatulence, dysentery, diarrhoea, dyspepsia with loss of appetite, dropsy, fever, vomiting, anorexia, cough, bronchitis, enlargement of the liver and spleen, rickets, gout, diabetes and colonitis. An infusion of the seeds is a good cool drink for smallpox patients. The seeds are used in India to induce lactation during the post-natal period. The seeds also find application in the synthesis of sex hormones as oral contraceptives. The powdered seeds are used *in* veterinary medicines. An

aqueous extract of the seeds possesses antibacterial property.

The seeds are also used in hair tonic preparations. A mixture of fenugreek and cotton-seed powder fed to milch cattle will increase the flow of milk. The seeds are good for the elimination of bad breath and body odour. The flowers are also used for flavouring. 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.

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.

Botany:

There are two species of the genus *Trigonella*, which are of economic importance, viz., T *foenum graecum* or the common *methi* and T *corniculata* or the Kasthuri *methi*. Fenugreek is an annual herb, 30 to 90 cm tall, and has light green leaves which are pinnately trifoliate. The flowers are papilionaceous and white or yellow in colour. The stigma becomes receptive 12 hours before the flower opening and remains receptive for about 10 hours after the opening of the flowers. The plants flower in about 30-37 days after sowing and the duration of the flowering phase is 7-8 days. The species is typically self-pollinated and destogamous. The pollen fertility ranges from 95-98% in the unopened flower buds and 67-80% in the open flowers. The plant produces slender beaked pods, 10 to 15 cm long, which mature within 60-70 days of sowing. A pod contains 10 to 20 small, hard, yellowish-brown seeds, which are smooth and oblong, about 3 mm long. It is pleasantly bitter in taste and possesses a distinct flavour of its own.

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 (Prabha)

This is a pure line selection from the Nagpur local released in 1989. 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. The plants flower in 60 days.

RMt 143

The grains of this variety are bold with a 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 the heavier soils of the Chittor, Bhilwara, Jhalawar and Jodhpur areas.

CO-1

This is a reselection from TG 2336 of IARI, released in 1982. 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. It is a quick-growing, dual-purpose type.

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.

Rajendra Kanti

This is a mass selection (RM 16) from the Reghunathpur germplasm released in 1987. Its plants are tall and bushy green with medium-sized, golden-yellow seeds and is moderately resistant to powdery mildew, caterpillar and aphids and *Cescospora* leaf-spot. It matures in 120 days with an average yield of 12.50 q/ha. The variety takes 45 days for flowering. It is suitable for inter-cropping in both the kharif and rabi seasons.

Lam selection 1

This is a selection from the germplasm collected from Madhya Pradesh, released in 1992. 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. It is a dual-purpose, early maturing type and gives a high yield of greens. It takes 35 days to flower.

Hissar Sonali

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

HM 103

The plants of this variety are bushy, semi-erect with bold, yellow, attractive seeds. It is moderately resistant to the 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.

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.

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. 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 60:90:50 kg NPK/ha. Recommended for Bangalore 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. GA_3 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 odourous.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micro-propagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
11. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
12. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

FENUGREEK

Questions:

I. **Choose the correct answer in the following:**

1. In India, Fenugreek is commonly called as

   a) Palau b) Methi c) Mint d) None of these

2. The scientific name of fenugreek is

   a) T Lycopercicum esculentum b) T Foenum graecum

   c) Foeniculum vulgare d) None of these

3. Which is the leading state in fenugreek production.

a) Rajasthan b) Maharastra c) Chennai d) Gujarath

4. The average grain yield of fenugreek is about.

a) 5-10 q/ha. b) 10-15 q/ha. c) 15-20 q/ha. d) None of these

5. Which is the growth regulator used to improve the seed number and size.

a) Phosphoric acid b) Acetic acid c) Sulphuric acid d) Ascorbic acid

II. Write whether the following sentences are True or False:

1. Fenugreek is the first largest seed spice in India.
2. Fenugreek seeds are used in hair tonic preperations.
3. A seed rate of 15-25 kg/ha. is used for fenugreek seed crop.
4. The ideal sowing time for fenugreek in North India is from the last week of November to first week of December.
5. The optimum pH for best growth and production of fenugreek is 7-8.

Answers

I

1	b
2	b
3	a
4	b
5	d

II

1	False
2	True
3	True
4	False
5	False

DILL

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 indigenous medicines. The essential oil, dill oil or its emulsion in water (dill water) is considered to be an aromatic, carminative specially useful in control of flatulence, colic and hiccups in infants and children. The residue of the seed after the extraction of the volatile oil is reported to contain about 16.8 percent of fat and 15.1 percent of protein and can be used as cattle feed. The amount of component responsible for the aroma (hexahydrobenzofuran) in herbs varied between 4.5 and 7.5 mg/g DW. The essential oil is also used in the manufacture of soaps.

Dill leaves are used for seasoning soups, salads, processed meats, sauces and particularly pickles. The seed is employed as a condiment in India and is also used as a carminative, aromatic stimulant and diuretic in *Ayurvedic* and *Unani* medicines. The emulsion of the seed oil in water is an important constituent of gripewater, useful in flatulence, colic pain, vomiting, diarrhoea and hiccups.

The European dill seed oil is preferred in Pharmacy over the seed of the Indian dill or `sowa' due to the presence of a large percentage of dillopiole varying from 15.6 to 39.6% and a lower percentage of carvone in the sowa seed oil. Dillopiole is a toxic substance, not found in European dill seed oil. The dried residue left after the distillation of essential oil from seeds of *A. graveolens* contains fat-16.8% and protein-15.1%. This may be used as cattle feed.

Origin and distribution

Anethum graveolens is a native of the Orient and Mediterranean countries, and is found growing wild in Iran, Egypt, Abyssinia, various parts of Europe, Southern Russia, Africa and Asia. It is cultivated in the United States, Hungary, Germany, Holland, Sweden, Asia Minor, North Africa, India and England. In India, it has been successfully cultivated on an experimental scale in Jammu and Kashmir, Maharashtra, Gujarat, Andhra Pradesh, Madhya Pradesh and Rajasthan. Indian dill is a native of Northern India.

Botany:

Dill is a hepaxanthic annual or biennial aromatic herb, growing to a height of about 1 to 1.20 m. The leaves are feathery and stand on sheathing foot-stalks, with linear and pointed leaflets. The leaves are compound and light green in colour. The stem is smooth, shiny and hollow, having an upright growth and bearing flat terminal compound umbels, with numerous

yellow flowers, whose small petals are rolled inwards. The flowers are regular, bisexual, pentamerous and dichogamous. The fruits are flat, dry and groomed, commonly but erroneously these so-called seeds are produced in great quantities. They are very pungent and bitter in taste and are very light in weight. It consists of two brown, broadly oval, compressed, indehiscent, one-seeded carpels (mericarps), 3-4 mm long and 2-3 mm broad, with a thickness of 1.0 mm. They have five ridges, the three dorsal ridges being inconspicuous, brown, and the other two being lateral, yellowish and wing-like. The chromosome number is 2n=22. The seeds of the Indian dill are especially bold (large and good looking). They also tend to be longer and narrower in shape and their oil has a somewhat different profile.

Climate

Dill is quite a hardy plant and may thrive in much cooler climates, provided it finds a warm situation. It is a long day, cold weather crop, growing during the *rabi* season in the Indian plains. Strong winds and heavy rains during the flowering period may be injurious and extreme heat during maturity reduces the oil yield.

Soil

Dill grows well in any good garden soil with high fertility, sandy loam soils with good drainage being most suitable. Light sandy or heavy clay should be avoided. It can be successfully grown in soils with a pH upto 8.6.

Varieties

‘Haldwani selection’ and 'English stock' are the varieties recommended for cultivation in India. Among the foreign varieties, `Gribovskii' is recommended for early sowing, and high herbage and seed yield.

A number of high yielding selections were identified in Indian dill. Of the selections, N.P. 127 and N.P. 179 were recommended for growing in the Indo-Gangetic plains, N.P. 115 for Gujarat and N.P. 15 for the hills. The average yield of these selections is around 1 to 14 t/ha.

Cultivation

Dill is propagated by seeds. The seeds are usually sown in March-April or in mid-October by drill or broadcast, in well-prepared land supplied with FYM @ 19 t/ha. The recommended seed rate is 3-5 kg/ha, sown in rows 60 cm apart and later thinned to a 30 cm

spacing after about 30 days from sowing when they are 13 cm high. The seeds have a viability of about three years and take 7-9 days for germination, when sown during the month of October, with 96 to 98% germination.

If the crop is sown late, the vegetative phase is reduced, which seriously lowers the yield of the seed crop. A spacing of 45 x 20 cm and sowing in lines 30 or 45 cm apart have also been found suitable for this crop.

Manures and fertilizers:

The crop responds well to the application of nitrogenous and phosphatic fertilisers. A dose of 40-90 kg N and 40 kg P_2O_5 required for getting good crop and yield. 50 % N and entire P_2O_5 are applied at the time of sowing, the remaining 50 % N is top dressed 30 days after sowing.

Weeding and irrigation

The plots should be kept free from weeds. Weedicides, Influtalin and Ethafluralin (1.1 kg/ha), Sethoxydim (4.5 kg/ha), Linuron (1 kg/ha), Chlorbromuron (4.5 kg/ha), Thiobencarb (6-8 kg/ha), etc., have been recommended for chemical weed control. Since it is a herbaceous crop, regular irrigation at an interval of about 8 to 12 days, depending on the soil and climatic conditions, is necessary. Generally, 8-9 irrigations are quite adequate for the maturity of the crop.

Intercropping

Dill can be intercropped with *Rauwolfia serpentina* or *Mentha arvensis* or *Salvia sclara.*

Use of growth regulators

Gibberellic acid (50 ppm) sprayed 15 days after emergence and again 10 days later, increases the yield and improves the flavour. Ascorbic acid (50 ppm) treatment is reported to yield oil with a high concentration of carvone and dihydroxycarvone and the lowest amount of dillapiole.

Harvesting

Harvesting should be done at proper stage and time, since the quality of oil depends upon the state of maturity of the herb and the fruits. The plants sown in mid-October will be ready for harvest by the end of April; i.e., the plants take about five and a half to six months for maturity. The main axis of the stem ends in a large-sized compound umbel, which is axillary in position, or in branches. The crop continues to produce umbels on the tertiary branches and these are at various stages of maturity, at harvest time for a seed crop. The crop is prone to shedding on maturity and, therefore, should be carefully collected at the right time of maturity.

Generally, for obtaining dill oil, harvesting is done when the crop is about $3^{1}/2$ months old and is in the milky, ripening seed stage and the most advanced fruits are turning brown. After harvest, the plants are allowed to wilt in the field for 1-2 days and then distilled. When the crop is grown for its fruits, it is harvested when most of the fruits are fully developed (ripe), but still green in colour. The fruit at this stage contains maximum oil and carvone content and this procedure also avoids the shedding of seeds. To avoid shedding in very dry weather, harvesting is preferably done early in the morning, when the plants are still damp with overnight dew. The harvested material is dried in the field till the fruits can be easily threshed. The threshed fruits should be spread in a thin layer and frequently turned over until thoroughly dry. The seeds, after drying and cleaning, are packed in gunny bags and kept in a cool and dry place. Dill has a shelf-life of 6- 9 months.

Yield

The herbage yield is about 2.5 to 3.0 t/ha, which on distillation gives about 18-20 kg of oil containing 30% of carvone, while the seed yield is about 5 to 7 q/ha.

Distillation

The essential oil is extracted by steam distillation from the herb, including the immature fruits and also from the mature and separated fruits. The two oils, however differ in composition, odour and flavour. The herb or 'weed' oil (isolated from the above-ground parts, including the unripe seeds) is preferred by the food industry, because of its more

characteristic dill herb flavour. The seed oil, with its high carvone content, resembles the oil of caraway. During recent years, dill-herb oil has largely replaced the fruit oil for flavouring and seasoning purposes.

Value-added products

The value-added products of dill are dill-seed powder, dill-seed oil, dill weed (dill leaves), oleoresin dill, etc.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

10. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
11. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

DILL

Questions:

I. **Under line the correct answer in the following:**

1. The major constituent of dill seed oil is

   a) Carvone b) Acetone c) Methane d) All the three

2. Which is the best suited variety of dill recommended for cultivation in India.

   a) English stock b) Standard bearer c) Improve Japanees

   d) None of these

3. How many irrigations required for Dill crop.

   a) 7-8 b) 8-9 c) 9-10 d) 10-11

4. Dill is propagated by

   a) Cuttings b) Seeds c) Suckers d) None of these

5. Essential oil of dill is used to manufacture

   a) Soaps b) Perfumes c) Hair oil d) All the three

II. . Match the following:

Part-A		Part-B	
i	Aroma in Dill	a	16. 8 %
ii	Fat content in essential oil of dill seed	b	1.2 to 4 % volatile oil
iii	Protein content in essential oil of dill seed	c	2.5 to 4.0 % volatile oil
iv	Indian dill	d	Hexa hydrobenzofuran
v	European dill	e	15.1 %

Answers

I

1 a
2 a
3 b
4 b
5 a

II 1 d
2 a

3 e
4 b
5 c

CUMIN

Scientific Name : *Cuminum cyminum* L.

Family : *Apiaceae/ Umbelliferae*

English name : Cumin
Indian name: *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* or *Jeeragom* (Tamil), *Jidakara, Jikaka* (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. In addition to this, seeds also contain a fixed oil (10%) with a strong aromatic flavour.

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).

Botany:

It is a small, slender, annual herb of about 30-45 cm height, with a much-branched angular or striated stem bearing 2 or 3 linear leaves, bluish green in colour and having a sheathing base. The flowers are white or rose coloured, borne in compound umbels. Calyx, five-toothed gamosepalous; corolla consists of five pink-coloured but sometimes white-coloured petals united at base; androecium consists of five stameans; anthers mature earlier than the stigma becomes receptive; gynoecium, two carpels with syncarpous inferior ovary, stigma persisting as distinct stylopodium. The commonly known cumin seed is size of schizocarpic fruit contains single seed.

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.

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.

Improved varieties:

RS-1

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.

UG-19

This has good attractive seeds and shows better resistance to wilt.

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.

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 (MC-43-73)

This is a pure line selection from M2 of y-irridiated seeds of MC-48. The plants are bushy with a good branching habit. It gives an average yield of 700 kg/ha. It is moderately resistant to *Fusarium* wilt, *Alternaria* blight and powdery mildew diseases. The variety matures in 100 days.

Gujarat cumin-3

This variety (culture sel. 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 (98 days). The plants are a bushy type (21.8 cm). The variety produces 663 kg/ha and possesses 3.3% essential oil. The seeds are pungent with a good aroma and are dark grey in colour.

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.

RZ-19 (Rajasthan zeera-19)

This is a recurrent selection from UC-19 made at the SNJ College of Agriculture, Jobener, Rajasthan. This is a late variety, maturing in 125 days and is well adopted to late sown conditions. The variety can yield 500 kg/ha and is tolerant to *Fusarium wilt* and *Alternaria* blight diseases.

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.

UC-52, UC-91 NP ()-1, NP (J) 126, NP (J) 149, Rcr 1 g are the other recommended varieties of cumin. The exotic cultivars EC-232684, EC-243373, EC-243375 and EC-109635 are found resistant to *Fusarium* wilt disease.

Cultivation

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. Normally, if sowing is done properly, the seeds germinate in 5-7 days.

Manures and fertilizers:

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 25:20:20 or 50:50:80 kg or 30-40 kg each of NPK per hectare is considered to be optimum for the satisfactory growth of the crop. Half the dose of N, the whole of P_20_5 and K_20 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.

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, an 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 a 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.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

10. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
11. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

CUMIN

Questions:

I. **Under line the correct answer in the following:**

1. What is the botanical name of cumin.

a) *Cuminum cynimum* b) *Cymin cumin* c) *Apium cuminum* d) None of these

2. Cumin belongs to the family

a) Cruciferae b) Umbelliferae c) Zingiberaceae d) Alliaceae

3. Voltile oil content in cumin seed is

a) 8-10 % b) 0-1 % c) 2.5-45 % d) 15-18 %

4. Origin of cumin is

a) Mediterranean region b) Africa c) India d) South America

5. Optimum soil pH range for cumin cultivation is

a) 4.5-6.0 b) 5.5-6.0 c) 5.0-7.0 d) 7.0–9.5

II. Write whether the following sentences are True or False:

1. Cumin is an annual herbaceous plant.
2. Cumin is a temperate crop.
3. RS-1, RZ-19, UC-217, UC-220, are the varieties cumin.
4. Sel. 7-3 variety of cumin (IARI) is resistant to wilt disease.
5. The old cumin seeds yield more essential oil than fresh ones.

Answers

I

1	a
2	b
3	c
4	a
5	d

II

1	True
2	False
3	True
4	True
5	False

CELERY

Scientific Name : *Apium graveolens* Linn

Family : *Apiaceae / Umbelliferae*

English name: Celery
Indian name: *Shalari*, *Ajmud* (Hindi), *Bandhuri*,*Chanu* (Bengali), *Bodiajmoda* (Gujarati), *Ajmoda* (Marathi), *Kernauli* (Punjabi), *Ajamoda* (Sanskrit), *Ajmoda* (Tamil)



Celery is on herbaceous plant grown for its leaves, seeds, oleoresin and essential oil. Celery seed is known for over 3,000 years. The main variety cultivated in India is *Apium graveolens var. dulce*.

The seeds contain a pale yellow essential oil (1.75%) which consists of limonene (80%) as a major constituent. The seeds are also rich in vitamin B.

The dried ripe seeds are used as spice to flavour food and liquids. The seeds are stimulating and carminative, used as a nerve tonic in domestic medicine. It is also a remedy for rheumatism. The seed oil is used as a food flavourant, and in perfumery and pharmaceutical industries. The fatty oil obtained from the fruit is used as an antispasmodic and nerve stimulant.

Origin and Distribution

The native habitat of celery is the lowlands of Italy from where it spread to Sweden, Egypt, Algeria and Ethiopia, and in Asia, to India, the Caucasus and Baluchistan. Celery is also claimed to be mentioned for the first time as a cultivated food plant in France as early as 1623. The countries growing it are the USA, France, Germany, United Kingdom, Italy, Belgium and Holland. In India it is cultivated in the Northwestern Himalayas, the Punjab, Haryana and Western Uttar Pradesh.

Area and Production:

In India the area under this crop is about 5,000 hectares, Punjab contributes to about 90% of the total Indian production. Celery seed is in great demand both in India and abroad. Indian celery seed is exported mostly to the UK and USA and to a lesser extent to continental

countries like France, Italy, the Netherlands, Germany as well as Australia and New Zealand.

Botany:

Celery is a herbaceous annual or biennial erect herb growing to a height of 60-90 cm. It has a shallow taproot system. The stem is branched, succulent and ridged. The leaves are reduced, pinnate, large, deeply divided and coarsely-toothed at the apex. The leaflets are ovate to suborbicular, 3-lobed, 2.0-4.5 cm long. The inflorescence is a compound umbel. The flowers are small and white and the calyx teeth are obsolete. There are five ovate, acute petals, with their tips inflexed. The carpels are semi-terete, sub-pentagonal, the primary ridges being distinct and filiform. The fruit is a schizocarp with two mericarps, suborbicular to ellipsoid, 1-2 mm in diameter, aromatic and slightly bitter. Celery is naturally cross-pollinated but not self-incompatible.

Climate

Celery thrice the best when the whether gives rate will be cool and having moderate and well distributed rainfall during its growing period. The places having low humidity or higher temperature causes bitterness in the leaves. The crop bolts when temperature falls below 15^{o}C. It is behaves as annual plant in plains and in cold it behaves as a biennial plant.

Soil

Celery can be successfully cultivated on all soils except saline, alkaline and water-logged soils. However, loamy soils which are rich in organic matter and retentive of soil moisture are the best. Celery is not suited to clayey soils. It does not withstand water stagnation. Celery is sensitive to the extremes of soil reaction; a soil pH range of 6.0 to 7.5 is suitable for its cultivation.

Varieties

The important high yielding varieties recommended for cultivation under this crop include EC-99249-1 and RRL-85-1. The selection RRL85-1 yields 2-3% yellow volatile oil. It has 16-20% fatty oil. 'Standard Bearer' and 'Wright Grove Gaint' are the varieties of celery recommended for cultivation by IARI, New Delhi, for salad purposes. The characters of these varieties are as follows:

1. Standard Bearer: Early, medium tall plant, medium pink stems with white longitudinal streaks, stalks solid and of good size and flavour.

2. Wright Grove Giant: Medium, late, tall growing plants, produces large white stalks of fine quality, immense cropper.

Cultivation

Propagation:

Celery can be propagated from seeds, by raising the seedlings in nursery beds. The seeds are quite small. An ounce contains about 70,000 seeds. The germination rate of seeds is about 50%. A seed rate of 1.5 kg per hectare is sufficient. The seeds are sown in boxes and covered with thin layers of soil and FYM mixture. The seedlings are ready for transplanting when they are about 10 cm tall (60-70 days after sowing).

Tissue culture

The major breakthrough in tissue culture research is the encapsulation of somatic embryos from hypocotyl segments, thus leading to the production of artificial celery seeds.

Land preparation

The land is brought to a fine tilth and laid into plots of convenient sizes for irrigation. It is preferable to mix with the soil 10-20 tonnes of FYM/ha during the last ploughing.

Sowing/transplanting

When it is grown as a garden crop on the hills, the seeds are sown in March-April. The seedlings are transplanted in May and the crop is ready for harvest in November. In the plains, the seedlings preferably brought from the hills are transplanted in September-October and the crop is ready within three months. In the plains, the seeds are generally sown from the middle of September to October and the transplanting of seedlings, 30 cm apart in rows spaced at 30-45 cm, is carried out in January. It is also grown as a directly seeded crop, on a smaller scale in Amritsar District.

Manures and fertilisers

Before planting the seedlings, about 10-20 tonnes of FYM/ha is added. On medium soils, about 80-200 kg Nitrogen, 33-60 kg Phosphorous and 20-40 kg Potassium/ha is applied to the crop. Half of the Nitrogen, a full dose of Phosphorus and Potassium are applied in rows at the time of planting and the remaining Nitrogen is given as a top-dressing after one month. Sometimes Bo and Mn deficiency in soil can cause black heart and cracked stem, respectively and deficiency of Mg can cause chlorosis. In such soils, 10 kg each of Borax and Magnesium sulphate are applied at the time of land preparation (10 days before planting).

Irrigation:

The crop requires 10-12 irrigations at an interval of 8-7 days during the crop period.

Inter-cultivation:

Once established, the crop requires 3 to 4 hoeings to keep down the weeds. Application of chemical weedicides like Basalin (pre-planting) at 2-2.5 lit/ha or Stamp at 2 lit/ha or TOK-E-25 + Lasso @ 2.5 lit./ha or Fluchloralin 0.90 kg/ha and Pendimethalin 0.60 kg/ ha are reported to successfully control the weeds.

Harvesting and yield:

In cooler climates and on the hills, celery is a perennial plant and produces seeds only in the second year. It takes about 4-5 months from the time of sowing to seeding. In the plains, the crop matures in about 3 months after transplanting. The crop is harvested when about 80% of the buds begin to turn light brown. Since seed shattering is common, harvesting it in the early morning hours is advisable. The harvested crop is stacked in the field for a few days, and then threshed to obtain the seeds. Care is taken to avoid prolonged exposure to the sun. The seeds are cleaned by winnowing. They are graded through sieving and stored in gunny bags in a cool dry place. The average yield of celery is about 1000-1500 kg/ha.

Celery seeds yield 2-3% of pale yellow volatile oil with a persistent odour. The volatile or essential oil contained in the seed is isolated by steam distillation. The seed should be crushed and immediately put through distillation to avoid the loss of oil by evaporation. It is important that the seeds be evenly spread on the perforated grids with which a still serving for seed distillation should be equipped. The distillation of one batch lasts for 10-12 hours. The distillation wastes are usually redistilled.

Value-added products

Celery seed oil, celery herb (leaf) oil, celery chaff oil, celery seed oleoresin, celery salt, celery pepper, dehydrated celery leaves and freeze-dried celery are some value-added products.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
7. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
8. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
9. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
10. Nirmal Babu, K., Saji, K.V., Krishnamoorthy, B and Sarma, Y.R., 2001, Varieties of Spices, Developed at IISR, published by *Indian Institute of Spices Research*, Calicut.
11. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
12. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

CELERY

Questions:

I. **Under line the correct answer in the following:**

1. What is the botanical name of celery.

a) *Apium graveolens* b) *Anethum gravelolens* c) *Allium graveolens* d) None of these

2. Celery belongs to the family

a) Umbelliferae b) Alliaceae c) Crucifercae d) Zingiberaceae

3. Major constituent of celery essential oil is

a) Cuminaldehyde b) Limonene c) Capsanthin d) None of these

4. Which one of following is the variety of celery

a) Standard Bearer b) Wright Grove Giant c) Both a and b d) None of these

5. The colour of volatile oil extracted from celery is

a) Transparent white b) Green c) Blue d) Pale yellow

II. Write whether the following sentences are True or False:

1. Celery is a seed propagated crop.
2. Celery behaves as annual plant in plains and as biennial plant is cooler hills.
3. Average yield of celery is 5-6 t/ha.
4. Celery is a native of lowlands of Italy.
5. In India, Punjab is the major celery producing state.

Answers

I

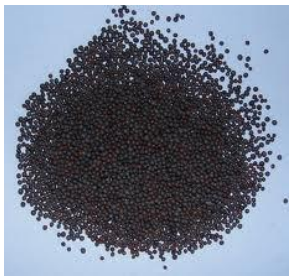
1	a
2	a
3	b
4	c
5	d

II

1	True
2	True
3	False
4	True
5	True

MUSTARD

Scientific Name : *B. Juncea* is popularly known as Indian Mustard
Brassica nigra B.alba / B. hirta/Sinapis alba (linn) Zernjajev.
Family : *Cruciferae*
English name: Mustard
Indian name: *Rai, Banarasi rai, Sufed rai, Kalee sarson* (Hindi), *Sasave* (Kannada), *Asuri, Bimbata* (Sanskrit), *Kadugo* (Tamil), *Avalu* (Telugu)



Mustard can be considered as one of our most ancient spices. It is also an important oil seed in India. Indian Mustard or Black mustard are valued as a condiment.

Origin and distribution

The plants of the genus *Brassica* are natives of the North Temperate Zone, but have passed into the sub-tropics and tropics as cold weather crops. There appear to be three major places of origin: Europe, Central and Southern Asia and China. Assam, Haryana, Jammu and Kashmir, Madhya Pradesh, Rajasthan, Uttar Pradesh and West Bengal are the major states that have the maximum area and production in the country. Recently, the crop is also being cultivated in the northern Telangana zone of Andhra Pradesh.

Area and production

Mustard occupies an area of 71,000 hectares in the country and the production is 6.9 Mt. This crop is commonly cultivated in areas of marginal and sub-marginal productivity, either as pure, mixed or as an inter-crop. Although in recent years, there has been an increase in the area and production of mustard, the average productivity (977 kg/ha) of the country is quite low in comparison to the developed countries.

Botany of different Mustards species :

A brief description, composition and uses of the various mustard species is given below.

1) White mustard *(Sinapis alba or B. hirta)*

White mustard is a self-sterile species, easily recognised by its hairy stem, devoid of any bloom. It has irregularly pinnate leaves, large yellow flowers that are spreading, and few-seeded and hairy pods. These have long, empty, knife-like beaks. The seeds are large, white and lightly pitted and give a considerable amount of mucilage with cold water. *S.alba* is a native of southern Europe and Western Asia. It is grown only as a garden crop, in temperate northern India, during the winter. In India, it does not contribute to the supplies of mustard or mustard oil.

Uses*:*

The seeds of B. alba are rarely used alone, they are usually mixed with black mustard in the preparation of mustard. They are not much used for the extraction of oil. In Europe, the oil-cake is used for fattening sheep. The young leaves and tender shoots are used as a pot-herb. The species is sometimes cultivated for green manure.

2) Black mustard or True mustard *(B.* nigra Koch)

Black mustard is highly self-sterile and is quite distinct from other brassicas. The fruits at maturity are closely appressed to the inflorescence axis. The seed-coat shows fine reticulations under a lens, and is mucilaginous. The outer epidermis is covered with a thin cuticle. B. nigra has been cultivated in Europe since the 13th century and is now reported to be growing wild. It appears to have been introduced only comparatively recently into India and is a cold season crop, grown to a limited extent in Uttar Pradesh, Punjab and Tamil Nadu. It does not contribute to the supplies of mustard oil.

Uses

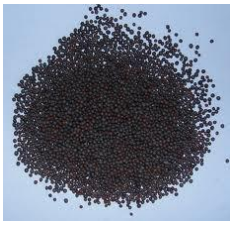
Black mustard is ground with white mustard for preparing table mustard and also various medicinal mustard preparations, such as a mustard bath, mustard bran, and mustard flour. The expressed oil has mild rubefacient properties and is used as a liniment. The technical oil obtained during the preparation of mustard also contains the oil from white

mustard seeds. In Europe, it is used for making soap, for burning and as a lubricant. In India, seeds of black mustard are used in pickles and curries.

3) Indian mustard (B. juncea)

Indian mustard is also a self-fertile species, and is a very variabie annual. Its narrow-based leaves are not stem-clasping like those of a *toria* and *sarson. Rai* matures later than either. The seeds are rugose, reddish-brown, and generally smaller. There are two races of rai: a tall, late race and a short, early race. The latter is again divided into rough-leaved and smooth-leaved types.

B. *juncea* is a common field crop of Bihar, Uttar Pradesh and Bengal and is found in almost all the brassica areas of India. Its cultivation extends westwards to Egypt and Europe and eastwards to China. It is also cultivated in Afghanistan.



Uses

Rai is an efficient substitute for black mustard. The USP recognises this species also as mustard. 'Brown mustard' and the 'expressed oil of mustard prepared from the seeds of B. juncea are included in the IPC. The former should contain not less than 0.6% of allyl-isothiocyanate. In studies of the preservative properties of spices, condiments and herbs with respect to their effect on yeast fermentation in wines, etc., mustard flour was easily found the most efficacious.

Climate

Mustard is a cool season crop. To get a better yield of mustard, sowing should be done when the maximum temperature is around 30°C with a relative humidity of 40%. If the temperature is high, sowing should be delayed. However, delayed sowing reduces the seed yield drastically. The best time for sowing is mid-October to mid-November; October sowing gives an increased yield. Sowing beyond November not only favours the incidence of aphids and other sucking pests but also causes reduction in the total phytomass production and ultimately results in lower yields.

Soil:

Mustard is found growing on a wide variety of soils from heavy clay to silt barns. However, it grows well in medium to heavy soils, which have good drainage. Saline–alkaline

soils are not suitable for its cultivation. Soils with a neutral pH (6.5-7.5) are ideal for its cultivation, but it can be grown on saline soils as well.

Varieties

The important varieties/hybrids recommended for cultivation in different parts of India are given in the table below.

Dominating *varieties*

STATE	CROP	VARIETIES
Punjab	Indian mustard	RLM 514, RLM 601, RL 1359, PBR-91, PBR-97, PHR-2*
Haryana	Indian mustard	RH 30, RH 8812 (Laxmi), RH 781, RH 8113, RH 819
Himachal Pradesh	Indian mustard	RCC 4, RL 1359
Iari , Delhi	Indian mustard	Pusa Bold, Pusa Bahar, Pusa Jai Kisan, (Bio-902), Agrani (SEJ-2), Jagannath (VSL-5)
Madhya Pradesh	Indian mustard	Kranti, Narendra rai, Pusa Bold, Rohini, Vardan, Varuna
Uttar Pradesh		
Pantnagar	Indian mustard	Karnti, Krishna, PHR-7*
Faizabad	Indian mustard	NDR 8501
	Yellow Sarson	NDYS-2
Kanpur	Indian mustard	Varuna, Vardan, Vaibhav, Rohini, Urvashi, PHR*
Rajasthan	Indian mustard	Arawali (RN 393), Rajat (PCR-7)
Gujarat	Indian mustard	GM-1, GM-2, Pusa Jaikisan, Rajat
	Yellow Sarson	Gujarat Sarson-1
Bihar	Yellow Sarson	Rajender Sarson-1, Swarna
	Indian mustard	Kranti, Pusa Bold, Varuna
West Bengal	Indian mustard	Seeta (B-85), Bhagirathi, Sarma, Pusa Agrani, Sanjucta asech
	Yellow Sarson	Benoy (B-9), Subenoy, Jhumka (YSBNC-1)
Assam	Indian mustard	Pusa Agrani, TM 4, Varuna
Maharashtra	Indian mustard	Pusa Bold, Pusa Jaikisan, Rajal
Andhra Pradesh	Indian mustard	Bhavani, PT 303, GMI, Divya, Kranthi, Vardan, Varuna

Aravali mustard, RH 30, RH 819 and Vaibhav are drought-tolerant. The variety RH 781 is frost-tolerant, whereas the varieties S 52 and Narendra rai are salt-tolerant. The variety Sourabh (RH 8113) is moderately tolerant to *Alternaria* blight and white rust. The varieties Pusa bold and Sarma are suitable for late sowing. The variety RT-11, evolved in Uttar Pradesh, is the most aphid resistant. The variety RH 30 is also suitable for late-sown conditions, while Kranthi is resistant to shattering.

Cultivation

Mustard is propagated through seeds. About 8-12 kg ha of seeds are required for sowing by broadcast and 5-10 kg/ha for line sowing. The seeds are treated at the time of sowing with Apron SD 35 (@ 6 g/kg) for the control of white rust and downy mildew at the seedling stage. To protect the crop from other seedling diseases like root-rot, wilt etc., the seeds are treated with Carbendazim or Thiram or Captan 2 g/kg) or Mancozeb (@3-4 g/kg of seed).

Land preparation

The land is ploughed by giving 5-6 criss-cross ploughings followed by plankings. In areas where clodding and their breakage is a problem, a three, strip bamboo ladder should be used. About 20-30 tonnes of FYM or decomposed cowdung should be mixed with the soil at the time of the last ploughing. One pre-sowing irrigation should be given at a depth of 5 cm, if there is less moisture in the field.

Sowing

The seeds are broadcasted over the well-prepared land and planked in the broadcast method of sowing. But line sowing is preferred over the broadcast method, as line sowing gives a better yield and helps in better management. A spacing of 30 cm between rows and an inter plant spacing of 10-15 cm has been recommended for this crop.

While sowing, care should be taken so that the seed does not come into contact with the drilled fertiliser, as this affects germination. For this purpose, the seed should be sown 3-4 cm deep, whereas the fertiliser should be drilled at 7-10 cm depth. To ensure good germination and early seedling vigour, the seeds must be soaked in water before sowing. This is done by covering the seeds with a moist gunny bag or directly with damp earth overnight. In the line-sown crop, the seedlings are thinned within the row two weeks after sowing to maintain the optimum plant population.

Manures and Fertilizer:

The crop responds to both organic and inorganic fertilizers. Apply well decomposed organic manure of 20-30 tonnes FYM and fertilizers @ of 40 + 35 + 15 kg NPK per hectare at the time of sowing. In hilly areas, it is recommended to apply 45 + 35 + 10 kg NPK per hectare. In acidic soils, especially in rice growing areas, lime should be applied atleast 30 days ahead of sowing. In the North Bank plains and the upper Brahmaputra valley zone, Borax should be applied to the soil @ 10 kg/ha.

Inter-culture:

In the early stages, the crop should be kept free of weeds. In orobanche-infested areas, one inter-culture is sufficient at 20-25 days after sowing. The predominant weeds of mustard are Chenopodium *album, Anagalis aruensis, Conuoluolus aruensis, Melilotus alba, Cynodon dactylon, Cyprus rotundus,* etc.

Weeding should be done soon after thinning. Three herbicides, viz., Fluchloralin, Isoproturan and Pendimethalin, are found effective in controlling the weeds of mustard. A pre-plant application of Fluchloralin @ 1.25 kg/ha and a pre-emergence application of Pendimethalin @ 1.25 kg/ha would prove effective. If the weeds emerge after planting, Isoproturon @ 0.75 kg/ha may be used 30 days after sowing.

Irrigation:

Mustard has a low water requirement. Generally six irrigations are given at 1, 5, 33, 50, 63 and 79 days after sowing. The first two irrigations should be light and the remaining with 75 mm water each. It is better to delay the first irrigation as much as possible. This helps the plants to branch well which, in turn, results in profuse flowering and fruiting. The best time for the first irrigation is 25-35 days after the sowing. The second irrigation should be given at the fruiting stage; i.e., 55-60 days after sowing.

Inter-cropping

Mustard can be inter-cropped with wheat, barley, gram, pea, sugarcane, lentil, *toria,* potato, etc., for better economic returns. It can also be grown sporadically as a sprinkle crop along with finger millet, groundnut, etc., or as a mixed crop along with chickpea, coriander, jowar, etc.

In orobanche endemic areas, it is recommended to adopt crop rotation with cereals or legumes.

Harvesting and yield

Depending upon the variety and its duration the crop normally matured will be in 80-120 days. Usually, the mustard crop is harvested as soon as 75% of the pods turn yellowish and moisture content of the seed is around 40%. At this stage, the majority of the seeds will be firm when pressed between the fingers. The oil content in the seed is the maximum at this stage. To minimise shattering losses, the crop should be harvested preferably in the morning when the pods are slightly damp with the night dew.

Bundles of the harvested plants are stacked and dried in the sun for a few days. Threshing is done by the usual method of treading by bullocks or by running a tractor over the dried plants spread on the threshing yard. The seeds are separated by winnowing. The moisture content of the seeds must be less than 8% at storage time. The yield per hectare ranges from 600-900 kg of seeds in rain-fed crops and from 900-1300 kg in irrigated crops. The seeds that are cleaned by winnowing are packed in gunny bags and stored in a cool, dry place.

Value-added products

Dried/Dehydrated mustard greens (leaves), powdered mustard or mustard flour, ground mustard (mustard meal), compounded mustard or mustard compound, mayonnaise, mustard cake, etc. are some value-added products of mustard.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
7. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
8. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
9. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.

10. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

MUSTARD

Questions:

I. **Match the following:**

Part-A		Part-B	
i	Mustard family	a	*Brassica hirta*
ii	White mustard	b	Cruciferae
iii	Black mustard	c	*Brassica juncea*
iv	Indian mustard	d	Rai
v	Brown mustard	e	*Brassica nigra*

II. Write whether the following sentences are True or False:

1. In India, mustard is mainly cultivated in Southern states.
2. Brassicas are natives of North temperate zone.
3. Mustard is a vegetatively propagated crop.
4. Mustard is a oil seed crop.
5. There will be higher shattering losses in mustard if the crop is harvested in the morning hours.

Answers

I

i	b
ii	a
iii	e
iv	c/d
v	c/d

II

1	False
2	True
3	False
4	True
5	False

LECTURE 15

Betelvine

Scientific Name : *Piper betle* Linn

Family : *Piperaceae*

Indian Name : Veledalae

English name : Betel leaf

Betelvine or *pan (Piper betle)* is a perennial, dioecious, evergreen creeper grown in India. It is a chewing stimulant. The crop is highly labour-intensive and particularly suited to small holdings. Once established, it becomes a perennial source of employment and cash flow for day-to-day income of the farmers. Betel leaf is on ther auspicious offering in Hindu customs particularly festival and wedding ceremonies.

The betel leaf occupies a significant place in everyday life of the Indian people. Other than its use in ethosocial rituals, chewing of the leaf or 'pan' as it is called, is an ancient habit among all classes of people.

The betel leaf is fairly rich in vitamin B and C, and is supposed to be a tonic to the brain, liver and heart. It clears the mouth and throat and helps digestion by encouraging salivation and neutralizing excess of acid by the lime eaten with it. The leaves contain an essential oil which gives the aroma and pungency to the leaves.

Origin and Distribution:

Betelevine *(Piper betel* Linn.) is a native of central and eastern Malaysia and has spread through tropical Asia and Malaysia. It was also taken to Madagascar and East Africa at a later date. It is an important cash crop in Andhra Pradesh, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal with an annual turnover of about Rs 700 crores. Its leaves are exported to Pakistan, Bangladesh, Indonesia, Malaysia, Burma and Thailand. In Karnataka, Chitradurga, Bellary, Uttara Kannada Dharwad, Chikkamagalore, Hassan, Mysore, Shimoga and Bangalore are the important districts.

Area and Production:

In India, the area under betelvine is 54,681 hectares with annual production of 17 million crores of leaves. The leaves are exported worth of Rs.18 million. Its leaves are exported to Pakistan, Bangladesh, Indonesia, Malaysia, Burma and Thailand.

Botany:

Betelvine belongs to genus Piper of the family *Piperaceae* which is having about 10 genera and over 1000 species of herbs, shrubs and climbers. About 65 species have been described in genus Piper. The species P. Betle is a perennial dioecious dictyledonous creeper with semi woody stem which climbs by short adventitious roots. Leaves are 5-20 cm long, broadly ovate to slightly coradate and offer unequal at the base, shortly acuminate, acute, entire with often an undulate margin, glabrous, yellowish to dark green, shining on both the surfaces; petiole is stout, 2.0 to 2.5 cm long. The plant produces orthotropic (vegetative) and plagiotropic (reproductive) branches. Growth rates in terms of stem elongation, number of leaves and branch production are higher in vegetative branches compared to reproductive branches. Vegetative branches also produce leaves with higher petiole length and intermodal length. The reproductive branches bear male or female flower in a plant. The male spike arising singly from leaf base are long, cylindrical and wavy, measuring 54-90 mm in length with a stalk length of 23-30 mm. The female spikes also arise singly from the axil and are short, stout, cylindrical and creamy-white to light orange in colour. The spikes measure 40-55 mm in length with a stalk measuring 19-26 mm. Individual flowers are small, sessile, 5-7 lobed with 3-5 stigmas. During maturation, irregular swelling called nodosites are formed on the fleshy fruits and their number varies from 5 to 7. The mature fruits possesses 2-20 spherical to oval, smooth surfaced seeds.

Climate:

Betelvine requires tropical climate for its luxuriat growth. The favourable conditions are moist soil and shady place with high humidity. It grows well where the rainfall is high (2250-4750 mm). It grows upto an elevation of 1,500 m MSL.

Soil:

It is generally grown on different types of soils-heavy clayey loam, laterite and sandy loam. However, soil with good organic matter and drain-age system is best-suited for its cultivation. It requires pH ranges between 7-7.5. Avoid saline and alkaline soils.

Varieties:

There are a number of varieties recognized by the growers and traders. Based on shape, size, brittleness, taste ofleafblade and other characters, betel vine is classified into different types-pungent and non-pungent varieties. The important varieties grown in different states are given in Table 1.

Table 1. Important betelvine varieties for different states

State	Varieties
Andhra Pradesh	Karapaku, Chennor, Tellaku, Bangla and Kalli Patti
Assam	Assam Patti, Awani pan, Bangla and Khasi Pan
Bihar	Desi Pan, Calcutta, Paton, Maghai and Bangla
Karnataka	Kariyale, Mysoreale and Ambadiale
Kerala	Nadan, Kalkodi and Puthukodi
Madhya Pradesh	Desi Bangla, Calcutta and Deswari
Maharashtra	Kallipatti, Kapoori and Bangla (Ramtek)
Orissa	Godi Bangla, Nova Cuttak, Sanchi and Birkoli
Tamil Nadu	Pachai Kodi and Vellaikodi
Uttar Pradesh	Deswari, Kapoori, Maghai and Bangla
West Bengal	Bangla, Sanchi, Mitha, Kali Bangla and Simurali Bangla

Bangla, Meetha, Sanchi, Kapoori, Deshawari, Khasi, SGM-1, Bidhan pan, DBP-6 are commercial cultivated varieties of betel leaves.

Propagation

Betelvine is propagated through cuttings having 3-5 nodes planted in such a manner that 2-3 nodes are buried in the soil. A single node cutting with a mother leaf is also planted. Cuttings of the apical and middle portions of the vine are used for planting. Cuttings are generally made from matures stem and it is collected from 2-3 years old plantations. Lower and tender portions of the plant take longer time to stout, moreover the lower portion of the plants are pruned to infection by phytophthora sp. Dipping of cuttings in 50 ppm NAA and IBA solution has been shown to increase the root formation and vigour of the crop.

Propagation of betelvine through seed is possible though not practiced. Flowering and formation of seed has been observed to occur sparingly in southern parts of India. Indian Institute of Horticultural Research, Bangalore has achieved some success in propagation through seed, which is helps for genetic improvements of the crop.

Betelvine is cultivated under fast-growing plants which provide support as well as shade. Under artificially-created shed known as *Boroj*, *Bareje* etc. it is also cultivated. Besides, mixed cropping with arecanut, coconut, jackfruit and mango is followed on a limited scale.

Cultivation

Construction of *Bareja* or *Boroj*

Barejas are normally made on raised slightly slopy land. It is constructed with locally-available materials-bamboo, jute sticks, straw etc. Its shape may be square or rectangular with a height of 2-2.5m. Usually a wide passage (0. 5-1. Om) is provided inside along the wall of the bareja. The walls and top of the bareja are covered with thatching material like leaves of coconut, wild datepalm, sugarcane, straw, grass and jute stick. It should be constructed near a source of irrigation. The site must be at a higher level than the adjoining area. There must be a slope in all directions for a quick drainage of excess water.

Raising of support plant in open cultivation

Plants of *Sesbania grandiflora, S. sesban, Erythrina variegata* and *Moringa oleifera* are raised to provide support and shade. They are sown in 45-60cm rows at least 45 days before planting the cuttings of betelvine. The proper wind break, quick growing freely branching and non competing crops are to be raised all along the border of the betelvine garden. Coconut, jack fruit, casurina, silver oak are grown for this purpose.

Land preparation

Land is prepared well by 4-5 ploughings. It should be raised by 5-10 cm from the adjacent areas. It is done by applying soil collected from ponds or tanks. The land is raised with proper gradient on both sides for quick drainage of excess water. Before use, the soil should be pasteurized by solarization technique. In Maharashtra, the selected land is ploughed twice and harrowed 4-5 times before levelling. In Madhya Pradesh, the land is first dug manually. Then it is irrigated, pulverized and levelled. Afterwards, beds of suitable size (15cm high and 30cm broad) are prepared.

Soil treatment

Soil is moistened occasionally and covered during hot summer months (March-May), hen the soil temperature rises sufficiently, to destroy inoculum of soil-borne pathogens. Soil polarization is advocated in Madhya Pradesh, West Bengal, Andhra Pradesh and TamilNadu before establishing new gardens for better plant stand and to minimize initial inoculum levels.

For new plantations, application of Carbofuran@ 1.5kglha or neem cake (0.5 tonneslha) + Carbofuran (0.75kglha) is also recommended to minimize initial soil nematode population. However, Carbofuran should not be recommended in established gardens at any stage because a time gap of 65-70 days as safe waiting period is required between application and harvesting of leaves.

Table 2 Planting seasons for different states

State	Planting-season
Andhra Pradesh	September-October
Assam	April-May and August-September
Bihar	June-duly, September and May-June
Karnataka	July-August
Kerala	May-June and September-November
Madhya Pradesh	January-March and September-November
Maharashtra	July-August and October-November
Nagaland	April-May
Orissa	
Tamil Nadu	May-June and September-November
Tripura	March-May and August-October
Uttar Pradesh	March-April and September-October
West Bengal	October-November
	June-July and September-October

Planting

The onset of monsoon is ideal time of planting. But where support plants are used, the planting may be done up to October-end, Nearly 40,000-75,000 cuttings are used for hectare where support crop is used, whereas 1,00,000-1,20,000 cuttings/ha are sufficient in bareja (closed) system of cultivation. Rooted cuttings raised in nursery are also planted. The planting season varies from state-to-state and even place-to-place. Most prevalent planting seasons are given in Table 2. 'Planting is done in rows. Spacings followed in different states under *Bareja* conditions are: given in Table 3.

Table 3. Spacing followed in different states

State	Spacing	
	Row-to-row	Plant-to-plant
West Bengal	50-70 cm	10-20 cm
Uttar Pradesh	100 cm	10-15 cm
Maharashtra	80 cm	20 cm
Bihar	80-100 cm	10-20 cm
Madhya Pradesh	50-60 cm	15 cm

In Karnataka Basin method, Begalum or Flat method, Deep trench system long bed and trench method, short bed method, Trench and furrow systems are adopted in cultivation of the crop.

Training/pruning

Young sprouts creep along and require support 1 month after planting. Trailing is done by tying vines on support crop or stalks. In *Bareja* system, jute sticks or bamboo sticks are placed by the side of the creeper as supports and tied with grass or banana fibre to facilitate trailing. Tying is also done at 20-30cm intervals when vine trails up to a height of 2.22 m and touches the roof of the *bareja.* They are untied from the support and lowered down to the ground level by harvesting the lower leaves, keeping 4-6 leaves at the top.

In open system, side branches of supporting trees are removed up to a height of 2 m for better growth of vines. Training is done by fixing the vines loosely along the standards with the help of banana fibre or easily available material at 10-15cm intervals. Training is done every 15-20 days depending upon the growth of vines.

Manures and fertilizers:

The recommended dose of manure is 25-50 tonnes per ha. in the form FYM, compost or supplemented with castor cake, linseed cake, sesamum cake or neem cake are applied as manure @ 15 quintals/ha. The cake is first rotted in water in a big earthen pot for 6-8 days. Then it is applied in the form of a slurry. Oilcakes in powder form are also applied in the rainy season. The NPK fertilizers @ 200:100:100 kg/ha/year has to be applied in 4-5 splits doses at 2-3 months intervals. In betelvine normally chemical fertilizers are not used, however the adequate quantity of manures should be applied for better growth and yield of seeds.

Trailing the Vines:

The sets begin to sprout and creep along in a month after planting. Trail the creeper to the supporting tree by tying the vines at an interval of 15-22.5 cm with the help of the banana fibre. When they come in contact with the supporting tree and strike advantageous roots which help them to climb further, attend trailing of vines for 15 to 20 days depending upon the rapidity of the growth of the vines.

Lowering of the Vines:

When the vines reach a height of 3-4 m. in one year's time, the vigour of the vine to produce normal size leaves will reduce. At this time, they need rejuvenation. This is achieved by lowering the vines down to the ground level at least once a year.

Betel vine is a crop demanding frequent irrigation. Wherever providing regular irrigation is not possible, burry a large portion of the exposed vine in the soil. Attend to the lowering of the vines either in the commencement of monsoon or at the end of the monsoon. Summer is the best time for lowering the vines. Before lowering do harvest all the leaves. Untie the vines from bottom upwards, coiled up carefully leaving 1 or 2 feet length of top shoots, then burry in a small trench dug at the base of supporting tree.

Lowering is done during March-April (1 time) in Uttar Pradesh, Madhya Pradesh and Bihar, during May-June in Andhra Pradesh; during January-February or April-May in Tamil Nadu and 3-5 times in West Bengal and Orissa. In West Bengal and Orissa, after every lowering stem is covered with loose soil brought from out side. In open system, soil is dug and stem is coiled and lowered and thereafter covered with soil.

Irrigation

Betelvine requires high soil moisture. Frequent light irrigation is necessary depending upon the season. Irrigation should be need-based. The flood irrigation should be avoided. Since over irrigation or excess water causes wilting of plants, proper drainage is essential during rainy season. The initial tests of drip irrigations systems in betel vine plantation has shown rich promise in Maharashtra.

Intercrops:

To get additional income, often many growers are cultivating intercrops, such as cucurbits, coccinia, chillies, ginger, banana, drumstic, brinjal, bendi etc., in North India. But, it is not common in other states.

Weeding:

The plots of betelvine should be kept free from weeds. Two to three manual weeding is done.

Harvesting:

Mature leaves are plucked along with a portion of petiole. They are plucked by hand without any aid. However, in certain areas iron nail is used to facilitate plucking. In Karnataka and Tamilnadu, leaves are plucked from side shoots. In south India, comparatively tender leaves are preferred in the market. After plucking, they are washed thoroughly and made into bundles according to the prevailing custom of the area. On an average, about 60-80 lakh leaves are harvested annually from one hectare garden.

Grading and Packaging:

Harvested leaves are washed, cleaned and graded according to their size and quality. Then they are packed after cutting a portion of the petiole and rejecting the damaged leaves. All growers do not grade their leaves. The picked leaves are sorted into different grades according to size, colour, texture and maturity. After that, they are arranged in numbers (the number varies from place-to-place) for packing. Grading and packing of leaves are very specialized jobs. For packing mostly bamboo baskets are used and in many places straw: fresh or dried banana leaves, wet cloth etc. are used for inner lining. In Tamilnadu, 100-200 leaves form a *Kavili* and 10 *kavilis* form a *palgai*.

Usually betel leaves are used for chewing as fresh unprocessed. But in certain areas, leaves are subjected to processing known as bleaching or curing. There is a good, demand for such leaves which fetch higher prices in the markets. Bleaching is done by successive heat treatments at 60°-70°C for 6-Shr.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
3. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
4. Edison, S., Johny, A.K., Nirmal Babu, K., and Ramadasan, A, 1991, Spices Varieties, published by *National Research Centre for Spices*, Calicut.
5. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
6. Horticulture Crops – Area, Production, Productivity and export statistics 2009-10 published by *National Horticultural Board*.
7. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
8. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
9. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

BETELVINE

Questions:

I. **Choose the correct answer in the following:**

1. Betelvine is a type of creeper

   a) Dioecious b) Monoecious c) Hermophrodite d) a and c

2. Betelvine is a native of

   a) Brazil b) Malaysia c) Moluccas d) Trinidad

3. The active principle of betelvine leaf is

   a) Anethole b) Curcumin c) Piperine d) Cineole

4. Ambadiale is popular variety of

   a) Andhra Pradesh b) Tamil Nadu c) Karnataka d) Kerala

5. Lowering of vine is practiced in the month of

   a) March-April b) December-January c) May-June d) September-October

II. State whether the following sentences are True or False:

1. 'Kavili' comprises 100-200 leaves popular grade of Maharastra.
2. Betelvine is non labour intensive crop.
3. *Sesbania grandiflora* is a popular standard for betelvine.
4. Betel vine is commercially propagated through seeds.
5. Deswari is the popular variety of Maharastra.

III. Match the following:

Part-A		**Part-B**	
1	Cuttings	a	IIHR, Bangalore
2	Seed propagation	b	Tamil Nadu
3	Vellaikodi	c	Intercrop
4	Silver oak	d	NAA 50 ppm
5	Cucurbits	e	Windbreak
		f	Maharastra

Answers

I

1 a
2 b
3 a
4 c
5 a

II

1 False
2 False
3 True
4 False
5 False

III

1 d
2 a
3 b
4 e
5 c

LECTURE 16

VANILLA

Scientific Name :*Vanilla fragrans syn.V.planifiolia Andrews., F*

Family : *Orchidaceae*

English name : Vanilla
Indian name: *Vanilla* (Hindi, Kannada, Malayalam,Tannil).

Vanilla is a spicy orchid, the product of Commerce is the dried and cured pods or beans of climbing orchid *Vanilla Planifiolia.* Cultivation of vanilla spread after discovery of America by Columbus. The aromatic qualities of vanilla beans were known long before discovery of new world. Once the vanilla ingredient was finally known in 1510, the Spanish conquerors imported vanilla beans from Mexico into Spain.

It is cultivated for its beans, which have a sweet scent, a heartful aroma and a pleasant flavour. Vanilla is the costliest spice in the spice horizon and is the important source of vanillin, which is used to flavour ice-cream, chocolate, beverages, cakes, custards and other confectionery. It also finds use in perfumery and medicine. The chief constituents of vanilla beans, in addition to natural vanillin (1.3-3.8%) are resins, fat, glucose, fructose, about 26 numbers of volatile constituents as well as 144 numbers of other volatile compounds and moisture. 'Vanilla sugar', obtained from the beans, is used in the manufacture of chocolates. Vanillin, the most abundant aromatic compound, is produced during the curing process. The synthetic vanillin produced from the waste sulphite liquor of paper mills, coal-tar extracts and from eugenol obtained from clove oil is much cheaper, but inferior in quality to the natural vanilla flavour. Further, after realising the carcinogenic effects of synthetic vanillin, the demand for natural vanilla in the developed countries increased several fold and it is having good scope for cultivation of this crop.

Origin and distribution

The crop is indigenous to South-eastern Mexico, Guatemala and parts of Central America but is now being cultivated in other parts of the tropics such as Java, Comoro Islands, Reunion, Mauritius, Madagascar, Tahiti, Zanzibar, Uganda, Tonga, Jamaica and other islands of West Indies. The history of this orchid spice starts from 1520 AD, however the commercial cultivation started only after 1814. This crop was introduced to India 200 years ago. In India, it is grown in Kerala, Tamil Nadu and Karnataka to a smaller extent.

Area and production:

The total area under vanilla in the world during 2000-01 was 40,846 ha with a production of 5,583 tonnes. Presently, Madagascar alone contributes 80% of the world production of vanilla beans. Three countries viz., US, France and Germany, account for 80% of the world imports. In India it is grown in an area of 2,545 ha. With a production of 100 tonnes. Kerala, Tamilnadu and Karnataka are the major states in cultivation of this crop.

Botany:

Apart from *vanilla planifiolia* other two important species which are economically important are:

Vanilla pornpona Schiede, known as West Indian vanilla, which occurs wild in Mexico, Central America and Trinidad and is cultivated to a small extent in Guadeloupe. It resembles V fragrans, but the leaves are larger. The flowers are also larger and more fleshy. The cylindrical pods are shorter and thicker.

V *tahitensis* (Tahitian vanilla) is indigenous to Tahiti and is cultivated there and also in Hawaii. It is less robust than V *fragrans* with more slender stems and narrower leaves. The pods taper towards each end.

Vanilla planifiolia is a fleshy, herbaceous perennial vine, climbing by means of adventitious roots up onto trees or other supports to a height of 10-15 m, but in cultivation it is trained to a convenient height to facilitate hand-pollination and harvesting. The adventitious roots are long, whitish, aerial, singly opposite to the leaves and adhere firmly appressed to the support upon which the plant climbs. The long, cylindrical, monopodial stem is simple or branched, succulent, flexuose, brittle and has internodes that are 5-15 cm long. They are dark green and bear photosynthethic leaves with stomata. The leaves are large, 8-25 cm long and 2-8 cm broad, flat, fleshy, subsessile and alternate, oblong-elliptic to lanceolate.

The tip is acute to acuminate and the base is somewhat rounded. The petiole is short, thick and canalised above.

The protruding inflorescences are axillary, racemose, usually simple, and only rarely branched, borne towards the top of the vine, with up to 20-30 flowers, opening from the base upwards, generally with only 1-3 flowers opening at one time and each lasting one day. The bracts are rigid, concave and persistent.

The flowers are large, waxy, fragrant and a pale-greenish yellow. The pedicil is very short and the ovary is inferior, cylindrical, tricarpellary. There are three sepals, which are obtuse to sub-acute and slightly reflexed at the opening. The two upper petals resemble the sepals in shape, but are smaller. The lower petal is modified as a trumpet-shaped labellum or lip, which is shorter than the other perianth lobes. Darker-coloured papillae form a crest in the median line, with a tuft of hair in the middle of the disc. The column or gynostemium is attached to the labellum. It is hairy on the inner surface, bearing at its tip the single stamen containing the two pollen masses or pollinia covered by a cap, and below is the concave sticky stigma, which is separated from the stamen by the thin flap-like rostellum

The fruit is a capsule, known in the trade as a bean, is pendulous, narrowly cylindrical, obscurely three-angled, 10-20 cm long and 1.5 and 4.5 cm in girth. It is aromatic on drying, containing when ripe, myriads of very minute globose seeds. In commercial production, the capsules are harvested before they are quite ripe.

Pollination

Vanilla is having peculiar structure of flower, which is not conducive for natural self pollination. In its native habitat, Mexico and Central America, some of the flowers are pollinated by stingless bees of genus Melipona and by humming birds. Elsewhere, hand pollination is unavoidable for fruit set. Even in Mexico, only a small percentage of fruits set naturally and hand pollination is carried out in commercial gardens. Pollination is performed with help of a pointed bamboo splinter, stem of a still grass or a sharpened tooth prick. Using one of these aids, rostellum is pushed back and overhanging anther is pressed against stigma with thumb and thus smearing pollen over it. Each flower lasts for a day only and so pollination should be carried out on same day. Ideal time for pollination is between 6 am to 1 pm. The fruit set % was maximum at 8 am and showed a decreasing trend as pollination get delayed. Studies showed that complete transfer of pollen result in maximum fruit growth and with less than 50 % pollen, fruit size gets reduced considerably. Hence, complete pollinia

have to be transferred to stigmatic surface so as to get maximum growth of fruit. A skilled worker on a average pollinates about 100 flowers a day. Flowers which are not fertilized fall off within a day or two. Normally eight to ten flowers located on lower side of inflorescence are pollinated and not more than 10-12 inflorescences in a vine. Remaining flower buds are nipped off to reduce strain on vine. Once fertilization takes place, the ovary elongates rapidly for 45 days until full length and full girth of beans are attained within 75 days of fertilization.

Climate

The crop thrives well in a warm, humid, tropical climate between 10^{o}N and 20^{o}S latitudes. It grows well upto elevation of 700 to 1500 MSL with an annual rainfall of 150-300 cm and a mean day temperature range of 25° to 32°C. Ideal relative humidity is 80 %. The rainfall should be well distributed for a period of nine months and the rest of the three months should be a dry period. Excessive humidity and moisture lead to diseased incidence, while a very dry climate and direct sunlight may cause yellowing by sun scorching. It can be grown successfully as an inter-crop in coconut, arecanut and coffee plantations.

Soil

Vanilla grows well in loamy soils as well as in laterite soils with plenty of organic matter. Any soil which has poor drainage should be avoided as the plant does not withstand water-logging. It prefers land with a gentle slope for better growth.

Varieties

There are no named varieties of vanilla as such. However, four major types of vanilla beans are distinguished in the world market, based on the countries of origin. They are: (1) Bourbon vanilla (produced in Madagascar, Comoro and Reunion); (2) Java vanilla (produced in the islands of Java in Indonesia); (3) Bourbon-like vanilla (mainly produced on the islands of Bali in Indonesia) and (4) Mexican vanilla. Among the four types, Bourbon-like vanilla ranks first in terms of quality.

ICRI, Myladumpara identified four genotypes viz., MCV-1, MCV-2, MCV-3 AND MCV-4 based on initial evaluation. These genotypes yielded consistently above 250 kg/ha under horizontal coiling system.

Cultivation
Propagation

Vanilla is commercially propagated by stem cuttings. They can either be planted directly in field or can be initially grown in polythene bags and transplanted after rooting. Cuttings with 8 to 10 internodes would be preferable as they come to flower earlier than shorter cuttings. Any part of vine with dormant axillary vegetative buds can be selected for taking stem cuttings. However, vines of current years growth which are in vegetative phase leaving tender shoots at tip are the most ideal. Length of shoot cutting used for propagation has a direct bearing on growth of vine and yield. Longer cuttings flower in second year itself whereas shorter cuttings take atleast three years to flower. Length of cutting is to be adjusted depending on availability of planting material and area to be planted. Cuttings shorter than 60 cm length are not recommended for in situ planting; instead they are rooted in polythene bags and then filed planted. For in *situ* planting cuttings with 60-120 cm length, 4 to 5 cm diameter, with 8-10 internodes should be taken from healthy vigorous plants and may be cut from any part of the vine.

A simple and rapid multiplication technique was developed at ICRI, Myladumpara for production of large number of cuttings from limited area. Rapid multiplication nursery is raised in 50 % shade. One meter cuttings are planted in trenches of 60 cm from wide and deep leaving 40 cm in between. Trenches are filled with top soil, well dried and powdered farmyard manure and sand in the ratio of 3:1:1. Standards for trailing of vines are planted at a distance of 1 meter along trenches atleast two months before planting vanilla. Vines are allowed to grow on supports and later coiled around branches of supports. Mulching, manuring and irrigation are given judiciously. A well maintained plant would produce about five to seven meters of growth per year. On an average one hectare of nursery would be sufficient to produce about 40-50 thousand meters annually.

For raising rooted cuttings, 2-3 noded cuttings are planted in polybags such that atleast one node is in potting mixture and two nodes above. The cuttings are tied on to

sticks planted in polybags. Partial shade should be provided either by using agro-shade nets or coir nets. Plants are maintained with regular watering and manuring. Cuttings will root in about 20 days and they will be ready for transplanting after six to seven months.

Micro-propagation:

Tissue culture is now acknowledged as reliable technology for large scale multiplication of quality planting materials of vanilla in a short span of time. The protocol developed at ICRI, Mayiladumpara. The Nodal segments of vanilla plants are used as explants.

Land preparation and Planting:

Vanilla being a climbing vine requires support for climbing. It flourishes well in partial shade of about 50% sunlight. Low-branching trees with rough barks and small leaves are grown for support. Under Indian conditions, Glyricidia has been found to be a good standard. Apart from *Glyricidia* other supporting trees used are *Jatropha Curcas, Plumeria alba, Casuarina equisetifolia* and *Erythrina* are used. The growth of the live standard should be adjusted so as to make them branch at a height of 120-250 cm. The standards are planted at a spacing of 2.5- 3 x 2 m (1600-2000 trees/ha). The best time for planting supports is with the onset of rains after the summer break, and it should be atleast six months before the vanilla planting. In one or two weeks, extension growth appears along with roots in the axils, which cling on to the support for climbing. Frequent inspections are necessary for turning of the shoots so as to enable proper climbing. The vines may be trained on trellises, or on other live standards like Bauhinia and silver oak. In the early stages, lateral shade may be provided by bananas and windbreaks should be planted if necessary. On account of the very superficial roots, no cultivation around the vanilla vines is recommended after planting.

The ideal time for planting vanilla is when the weather is neither too rainy nor too dry; planting in August or September can also be done under South Indian conditions. At the time of planting, the three or four basal leaves are removed from the cuttings and dipped in 1% Bordeaux mixture and kept in the shade to dry for about a week. They are planted at the rate of one per support at a spacing of 1.5 x 3.0 m. About 1,600 to 2,000 plants are accommodated in one hectare area as a pure crop.

After planting the cuttings, frequent irrigations are given and the basins are mulched with leaves and trash. While planting, about 3- 5 cm of the cutting is projected above the

ground and stakes are provided for the cuttings to climb and grow.

Manures and Fertilizers:

Organic matter and decomposed mulch, as the main sources of nutrients to vanilla. It loves decomposed organic matter. Well rotten cow dung, compost, well rotten poultry manure, vermi compost can be applied to promote growth of plant. Vermi compost may be applied at the rate of 10-20 per grown up vine. Though no research work has been done in detail regarding application of fertilizers. But, Vanilla can yield enhanced by soil application of 20;10:30 g NPK/vine/year and foliar application of urea, single superphosphate and muriate of potash at the rate of 1.0, 0.5 and 1.5 % respectively during January, May and September. Positive responses to application of biogas slurry and groundnut cake have been observed. Application of 40-60 g N as Ammonium sulphate or Calcium ammonium nitrate, 30 g P_20_5 and 60-100 g of potash in the form of muriate of potash per vine in two or three split doses promotes vegetative growth, leading to higher pod yields. The organic manures can also be applied in the form of leaf compost, starting from June-July. The application of fresh cattle manure has an adverse effect on the growth of the vines. The manures should be applied 20-30 cm away from the plant. Vanilla responds well to the foliar application of nutrients and therefore it is recommended that part of the fertiliser dose be given as a foliar spray before flowering. Spraying 1% 17:17:17 NPK complex on the foliage and stems has been found to be beneficial in enhancing the growth of the vines.

Irrigation

The crop requires moist climate for the better growth. Excessive rainfall and extended droughts are equally detrimental to the crop.. The soil around the vine should be kept moist. The aerial roots and leaves also absorb moisture from the atmosphere. Hence maintaining high relative humidity in vanilla plantation by using micro sprinklers and foggers will help in better growth of the plant. Timely irrigation should be provided in the initial two to three years of growth. During this period, a weekly irrigation of 2-3 litres per plant is sufficient.

Weeding

The land around the base of the vine should be free from weeds. The weeds growing at the base of the support tree around the plant, within a radius of 50 cm, should be pulled out and left *in situ* to decompose.

Training and pruning:

If the plant allowed to grow upon a tree, it will rarely blossom, so long as it is growing upward. Vanilla is to be trained to keep the vines within the limits for easy cultural operations. Vines are allowed to grow up to 1.5 m and then brought down. Vines are twisted around lower branches of supporting tree or over lattice of trillis so that they may hang down. Bending of vines appears to be an important factor in causing it to flower and fruit beyond the bend, which may be due to accumulation of carbohydrates and other flower inducing substances in that region of vine. If vegetative growth of vanilla vine are arrested by pruning, it turns to reproductive phase. At pruning time special bearing branches are prepared. These are shoots which when 1-1.2 m long are bent down with tip pruned at about 45 cm from soil. Any shoot produced on these branches is cut off when 7.5-10 cm long, but shoots appearing on rest of plant before bends are allowed to grow. They will constitute bearing branches of following year. As a result of decreased sap flow towards bearing branches, they flower. After harvesting the beans old branches are cut off. The practice of removing 10-15 cm growing shoot tip each year before flowering results in accumulation of carbohydrates, thus encouraging flower production in axils of leaves on e hanging branches.

In South India, planters follow their own techniques for pruning, the ultimate aim is to alter physiology of plant to prepare for reproductive phase. When harvesting is completed the whole branch which carries them is cut off and only new shoots of previous year are retained.

Shade management:

For shade management judicious lopping of branches of living supports is very important to adjust shade level to around 50 %. Under high rainfall and high relative humidity, vanilla can withstand more sunlight than during low humidity and drought periods. During flower bud formation and blossoming, more light is beneficial, but during dry periods support tree should maintain much of their foliage for providing shade. All pruned materials can be used as mulch.

Growth regulators:

Spraying of 2, 4-D and G.A. helps in development of Parthenocarpic beans. Length

and volume of beans could increase by swabbing the flowers bud with 2, 4-D (0.20 mg/flower bud. However, maximum growth and weight of beans were observed in hand pollinated beans. Experiments to improve vanillin content revealed that growth regulators significantly influenced quality of beans. Vanillin content fluctuated throughout curing period. After sun drying, hand pollinated beans showed a high vanillin content of 3.98 %. After slow drying period IBA (200 ppm) recorded the highest vanillin content of 4.22 % and after conditioning kinetin (200 ppm) recorded the highest vanillin content (4.20 %).

Intercropping:

Vanilla is a suitable intercrop under coconut, arecanut or any other tall crop, which provide shade. In recent times, vanilla cultivation is gaining importance as one of the intercropping components under high density multispecies cropping system (HDMCS) in coconut plantation. Coconut gardens of age between 8-10 years old offer favourable shade requirement of 50-60%. In between two rows of coconuts, two rows of standards are planted at 1.8 m x 1.8 m spacing and vanilla planted. In areca gardens, generally vanilla is planted on to areca plam itself and during 2nd year vines are trained by providing trellis in between areca palms.

Harvesting and Processing of Vanilla:

Vanilla plants starts bearing 2-3 years after planting depending upon the length of vine used for planting. About 9 -11 months are required for the fruit to mature after successful pollination and fertilization, depending on the temperature and elevation. The pods are harvested rotationally when they become fully yellow. The immature pods produce an inferior product and, if it is picked too late, it will split during curing.

The average yield of vanillery is about 300 kg/ha of cured beans per year. However, a good vanillery under better management can be yield 500-800 kg of cured beans. About 6 kg

of green pods produce 1 kg of cured beans. The curing should be done within a week of harvesting the beans. The yield may decline after 12-15 years of planting, and so replanting should be taken up.

Steps involved in processing of Vanilla beans.

Curing

There are different methods of curing the beans, viz., Mexican process, Bourbon process, Peruvian process and Guyana process. Under Indian conditions, either the Mexican or Bourbon process can be followed. During the process of curing alternate sweating and the yield of beans until moisture is lost by as much as 80 % moisture and beans undergo enzymatic reactions for production of vanillin which response well for the characteristic of flavor of vanilla. Basically curing method involves following four stages.

Killing or wilting

This process stops further vegetative development in the fresh beans and initiates the enzymatic (13-glycosidase) reactions responsible for producing the aroma and flavour. Generally for killing, the harvested mature beans are sorted according to their size viz., those above 15 cm and those below 15 cm are separately taken in an open basket, and are dipped in hot water with a temperature of 65°C for 3 minutes. Later, the basket is taken out and the hot water is drained off. Killing is indicated by the development of a brown colouration in the beans.

Sweating or fermentation

The killed beans are then subjected to sweating. This results in a rise in the temperature of the killed beans, which promotes the desired enzymatic reactions and hastens the drying period to prevent harmful fermentations. The sweating operation is carried out for two days, depending on the weather conditions. In warm weather, the pods are spread over blankets and exposed to the sun. During mid-day the blanket is folded over and bundled and left in the open for the rest of the day. They are wrapped in blankets in the night to maintain continuous fermentation and sweating. The pods should be wrapped in blankets when they are hot to touch. This process is repeated for 7-12 days till they become dark brown in colour, soft and flexible.

Slow drying

This is done at an ambient temperature in the shade, till the beans have reached about one-third of their original weight. The beans are dried for 17-22 days inside a room and will have 25-30% moisture in them.

Conditioning or aging

Here, the beans are stored in closed boxes in bundles of 25-30 tied together from tip to top with cotton threads and these bundles according to their size are wrapped in tissue paper. These wrapped bundles are again wrapped in woollen blankets and kept for a period of three months or longer in closed wooden boxes to permit the full development of the desired aroma and flavour.

Grading

There are four important grades. The first (best) grade beans consist of those above 16 cm in length, soft to touch without any blemishes and containing 2.5% vanillin. The second-grade beans consist of those of 12-15 cm length, without blemishes and with more than 1.8% vanillin. The third-grade beans are shorter, with a length of 8-12 cm and with some blemishes. The rest of the beans are taken as fourth (last) grade and are of poor quality.

The grades or types of vanilla (beans) entering the trade are:

Mexican vanilla
Bourbon vanilla (from Madagascar) Indonesian vanilla
Tahiti vanilla (from Tahiti)
Vanillons (from West Indies)

Extraction of vanillin

Gobley isolated the crystalline substance vanillin ($C_8H_80_3$) from the vanilla beans, first time during 1858. The vanillin extract is taken from the cured beans by hydro-alcoholic entraction. The finely-chopped beans are put in large stainless steel baskets and are immersed in a warm alcohol-water solvent in glass-lined or stainless steel percolators. The solvent, which has been piped in from the top of the vat, percolates down through the beans and on reaching the bottom is recirculated to the top to continue the percolation, until the maximum vanilla flavour is extracted. The freshly-percolated extract is drawn off, filtered, aged for about three weeks and bottled.

Vanilism (Vanilla poisoning)

Plant produces a fair quantity of oxalic acids in the leaves, stems and pods, on account of which the plant has to be handled with care. Too much of contact with vanilla creepers is reported to bring about an ailment called vanillism, which is characterised by heaviness of the head, skin irritation, fever and intestinal disorders. Vanilla poisoning may occur while planting and harvesting the green beans and also later during curing, especially during the conditioning operation. Therefore, it is better to wear rubber gloves while handling the vanilla beans.

Products of vanilla

The different products of Vanilla employed in flavouring are vanilla extract, vanilla flavouring, vanilla tincture (for pharmaceutical use), concentrated vanilla extract and concentrated vanilla flavouring, vanilla oleoresin, vanilla—vanillin extract and flavouring, vanilla powder, vanilla-vanillin powder, perfumery vanilla, vanilla absolute, etc.

: REFERENCES :

1. Bose, T.K., Mitra, S.K. and Farroqui, A.A., Sadhu, M.K., 1999, Tropical Horticulture – Vol.1, *Nayaprakash,* Calcutta, India.
2. Extension pamphlets of Black Pepper, Cardamom, Turmeric, ginger and Tree spices of 2009, published by *Spices Board*, India, Ministry of Commerce and Govt. of India, Cochin.
3. Extension pamphlet, Black Pepper, 2009, *Spice Board*, Cochin PP 3-24.
4. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
5. IISR, Annual Report 2010-11, published by *Indian Institute of Spices Research*, Calicut.
6. Nirmal Babu, K, Ravindran, P.N., Peter, K.V., 1997, Protocols for micro-propagation of Spices and Aromatic Crops, published by *Indian Institute of Spices Research*, Calicut.
7. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
8. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

VANILLA

Questions:

I. **Underline the correct answer in the following:**

1. The ideal time for pollination in vanilla is between

   a) 5 am & 12 noon b) 6 am & 1 pm c) 2 pm & 5 pm d) None of these

2. Based on the countries of origin, the vanilla beans are distinguished into ..... major types.

a) 5 b) 3 c) 4 d) 7

3. The standards for vanilla are planted at a spacing of

a) 2.5-3 x 2 m b) 3.5 x 2.5 m c) 2 x 2 m d) None of these

4. The curing of vanilla involves ..... stages.

a) 5 b) 4 c) 6 d) 3

5. The process which stops vegetative development and initiates reactions responsible for producing aroma and flavour is

a) Conditioning b) Killing c) Sweating d) Drying

II. Write whether the following sentences are True or False:

1. Vanilla is commercially propagated by stem cuttings.
2. Vanilla poisoning is called vanillism.
3. Killing or wilting in vanilla is indicated by the development of a red colouration in the beans.
4. The vanilla beans are divided into four important grades.
5. Spraying of 2, 4-D and G.A. helps in development of parthenocarpic beans.

Answers

I

1. b
2. c
3. a
4. b
5. b

II

1. True
2. True
3. False
4. True
5. True

LECTURE 17

CURRY LEAF

Scientific Name : *Murraya koenigii* (Linn.) Sprengel
Family : *Rutaceae*
English name: curry leaf
Indian name : Kathnim, Mitha neem, curry or kari patta, Gandhela, Barsanga (Hindi), karibevu (Kannada), Karriveppiler, Kariveppilei (Malyalam), Karivampu, Karuveppilei (Tamil), Karepaku (Telugu).

Curry leaf of commerce is the fresh and dry leaves of attractive, aromatic, more or less deciduous herb or a small perennial tree Murraya *koenigii* (Linn) Sprengel. Curry leaf is a spicy leafy vegetable used in our day-to-day culinary preparations, mainly to increase the flavour and taste of food. The leaf is economic part which slightly pungent, bitter with feebly acidic taste and the leaves retain their flavor and other qualities even after drying.

The fresh leaves contain 2.6% of a volatile oil (curry leaf oil) which may find use as a fixative for heavy type of soap perfume. Rectified curry-leaf oil is deep yellow in colour with a strong spicy odour and pungent clove-like taste.

The leaves of this plant have slightly pungent, bitter and feebly acidic taste, and they retain their flavour and other qualities even after drying and have been used for centuries in South India as a natural flavouring agent in various curries, sambar, rasam and *chutneys.* Ground curry leaf with mature coconut kernel and spices form an excellent preserve.

The leaves, bark and the root of the plant are used in indigenous medicine as a tonic, stomachic, stimulant and carminative. An infusion of the roasted leaves is used to stop vomiting. Externally, they are also used to cure eruptions and the bites of poisonous animals. The green tender leaves are eaten raw as a cure for dysenty. A decoction of leaves is sometimes given with bitters as a febrifuge. It has also been used as an antiperiodic, and many a time, the powdered dry leaf, mixed with honey and juice of betelnut is recommended in the *Ayuruedic* system of medicine. The aqueous extracts of the leaves, when administered parenterally to female guinea pigs, not only raise the phagocytic index but also mobilise a

greater number of leucocytes to take part in phagocytosis; the effect does not last long though. The juice of the root is taken to relieve pain associated with the kidney.

The fruit is edible. It yields 0.76% of a yellow volatile oil with a neroli-like odour and peppery taste, accompanied by an agreeable sensation of coolness on the tongue.

The wood (43-50 Ib/cft) is grayish-white, hard, even, close-grained, and durable. It is used for agricultural implements.

Origin and distribution

The crop is native to the Terai region of Uttar Pradesh in India and is found almost throughout India and the Andaman Islands upto an altitude of 1500 m. Sri Lanka, China, Pakistan, Australia and the Pacific Islands. It is commonly found in forests, often as gregarious undergrowth along the foothills of Himalayas from the River Ravi to Sikkim and Assam. It is also found in Bengal, Madhya Pradesh and South and the Southwestern States. On a commercial scale, it is cultivated in large areas in Tamil Nadu, Andhra Pradesh and Karnataka. In Tamil Nadu, the cultivation is concentrated in Coimbatore, Salem, Trichy and pockets of Ramanathapuram districts. In Coimbatore district, its cultivation is mainly concentrated in places like Karamadai, Mettupalayam, Thayanur, Kanvanur and in Thangacchimadam (Ramanathapuram Dist.). In Karnataka, it is being cultivated on plantation scale in Dharwad, Belgaum, Bellary and the Uttar Kannada districts.

Area and Production:

No exact statistics on area and production is available.

Botany

The plant is an attractive aromatic more or less deciduous shrub (0.9 m) or a small tree that grows upto 6 m height (in the Himalayan regions) and 15-40 cm in diameter. The bark is dark brown or almost black; the leaves are imparipinnate, with 9-25 leaflets that are ovate, lanceolate or somewhat rhomboid, irregularly crenate-dentate, acuminate, obtuse or acute. The base is usually oblique, almost glabrous above, pubescent beneath, gland dotted and strongly aromatic. The flowers are in terminal corymbose cymes, white and fragrant. The berries are sub-globose or ellipsoid, purple-black when ripe and 2-seeded. The roots are woody, widely spread and produce many suckers. The tree bears flowers from February-May and the flowers are self-pollinated, hence its variability is very limited. The diploid

chromosome number is 2n=18.

There are two important species:

Murrya paniculata	-	Chinese box wood (or) Andaman satin wood.
Murraya exotica	-	A popular hedge and well adapted for topiary.

Climate:

Curry leaf is hardy crop can tolerate higher temperature ranging from 26° to 37°C. But when the temperature falls below 16°C, the vegetative buds become dormant arresting the new growth of the plant. However, this varies from variety to variety. It can be grown in places upto an elevation of 1500 m MSL.

Soil:

Curry leaf can be cultivated in a wide range of soils. Red sandy loam with good drainage is ideal for its better growth and leaf yield. To a certain extent, also it can tolerate drought. Heavy clay with poor drainage is not suitable for its cultivation.

Varieties

1. **Senkaampu:**

It is a local cultivar grown in different parts of Tamil Nadu. The petiole is purplish-red in colour. The leaves have a good aroma and flavour due to its high oil content.

2. **DWR-1 (Suvasini)**

It is developed by UAS, Dharwad, a clone obtained from root suckers that have dark green, highly aromatic, shining leaves. It is sensitive to low temperature in the winter season and hence the bud burst is poor during winter. The leaves are dark green (0.1629 mg of chlorophyll content per gram of fresh leaf), shiny and highly quality (5-22 % oil) and made into dry powder. The plant could be trained to grow as a low bush (up to 90- 120 cm height). This variety is resistant to *Cylindrosporium* leaf-spot.

3. **DWR-2**

This is an open-pollinated seed progeny with pale green leaves with less aroma (5.09%). It is not very sensitive to low winter temperature and is much superior in the number of bud burst and internodal length. It is also 8 times higher in the growth of shoot length and weight of new shoots than DWR-1. Due to its winter tolerance, it can give extra income to growers.

Cultivation

Propagation

It is commercially propagated through seeds. Raising seedlings in the nursery and then planting them in the main field is the normal practice that is being followed. For raising seedlings, good and well-ripened fruits should be harvested from high yielding mother trees. Though there is stray flowering and fruit set throughout the year, the main season of availability of curry leaf fruits is July-August. Fruits are pulped and sown within 3-4 days of collection. The seeds are sown in nursery beds or polybags filed with soil and FYM. If seeds sowing is delayed germination of seeds are affected. Each fruit contains 2-3 seeds.

The nursery beds should be prepared in a well-drained area since water stagnation will severely affect germination. Beds of 1 m x 1 m size with 30 cm height are formed. Adequate FYM should be applied before preparing the beds. Lines are drawn at a spacing of 10 cm and seeds are sown in these lines. The seeds will germinate in about three weeks' time. The seedlings can also be raised in polybags. One-year-old seedlings are best suited for planting. Even young seedlings of about 3 months of age (20 cm in height) are planted in 15 cm^3 pits.

Apart from seed propagation vegetative propagation through root suckers, semi hard wood cuttings are also used for propagation. Soft wood cuttings, treated with 600 ppm IBA induced rooting upto 23 %. One year old root suckers are used. For large scale propagation of curry leaf, micro propagation was also tried. High frequency of direct shoot proliferation was induced in intact seedlings of curry leaf on modified Murashige and Skoog medium supplemented with benzayladenine (5 mg/1). Nodal segments from matured trees can also be used as explants.

Land preparation and planting

The land is prepared by ploughing 3-4 times to get a fine tilth. FYM @ 20-26 tonnes/ha. is applied. Pits of 30 cm^3 or 60 cm^3 size are dug, at a spacing of 1.2-1.5 m or 3-4 or 3 x 1.5 m (222tplants/ha) one month before planting the seedlings. A spacing of 90 x 90 could be adopted in soils with low fertility. Pits are filled with top soil and FYM. One seedling is planted at the centre of the pit. The seedlings can be planted during any season of the year. However, June-July planting is the best.

Manures and fertilizers:

The recommended fertilizers for the crop (g/plant/annum).

	Nitrogen	Phosphorus	Potassium
1st Year	50	25	25
2nd Year	150	37	37
3rd Year and above	300	50	50

The fertilizers should be applied in four divided doses (25% each application) at tri-monthly intervals after each harvest of leaves. After each harvest, 20 kg of FYM per plant is also applied and mixed with the soil.

Irrigation:

Light irrigation is given immediately after planting. On the third day the second irrigation is given; thereafter, irrigation is given once in a week. Flow irrigation method is adopted.

Weeding:

The crop should be free from weeds periodical hoeing in the first year and one inter-crop like pulses can be taken. The weeds can also be kept under check by spraying Paroquat (3 ml/lit). After each harvest, the field should be thoroughly weeded.

Intercropping

Leguminous crops like cowpea, black gram, green gram or soybean could be raised as inter-crops during the first year.

Pruning and training

In the initial stage, the terminal bud is allowed to grow upto an height of 1 m. After attaining this height, it is cut off to encourage basal branching. This will maintain the plant in a bushy state so as to facilitate the harvesting and other operations. About 5-6 branches are maintained per bush. Branches which grow tall in a vertical fashion have to be removed so that it will not become a tree. The first harvest started ten to twelve months after planting.

Harvesting and yield

The plants allowed to grow up to an height of 1 to 1.5 m during first year and it will

be harvested at this stage. The economic yields are obtained from the 2nd year onwards. While harvesting, the new shoots produced above the final pruning are harvested with sharp knives at the dense green leaf stage, crop is harvested four times in a year with an interval of three months. The yield of leaves per hectare is given below:

I year 250-400 kg of leaves/ha can be harvested.
II year : 1800 kg/ha once in 4 months, which works out to 5400 kg/ha per year
III year: Around 5400 kg/year.
IV year : 2500 kg/ha once in 3 months, which works out to 10,000 kg/ha/year
V year onwards: 5000 kg/ha once in 3 months, which works out to 20,000 kg/ha
The plants can be maintained for 25 years.

Post harvest management:

The young shoots with tender leaves are harvested, packed in gunny bags or tied in bundles and transported. Water is sprinkled on the bags/bundles. The leaves are dried and ground into powder and used as curry-leaf powder.

Value-added products

The value-added products of curry leaf are volatile oil and dehydrated curry leaves.

: REFERENCES :

1. Chadha, K.L., Retrinam, P 2010, plantation and spices crops., Advances in Horticulture, *Malhotra Publishing House*, New Delhi, INDIA, PP 293-345
2. Chadha, K.L., 2010, Hand Book of Horticulture, Indian Council of Agricultural Crops, 2006, *University of Agricultural Sciences*, Bangalore.
3. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
4. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.

5. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.

CURRY LEAF

Questions:

I. **Underline the correct answer in the following:**

1. Fresh curry leaves contain ..... present of volatile oil.

   a) 3.6 b) 2.6 c) 1.0 d) 5.0

2. The diploid chromosome number of curry leaf is

   a) 18 b) 22 c) 36 d) None of these

3. The local cultivar of curry leaf grown in different parts of Tamil Nadu is

   a) DWR-1 b) DWR-2 c) Senkaampu d) DWR-3

4. Curry leaf is propagated through

   a) Seeds b) Wood cuttings c) Root suckers d) All of these

5. The recommended fertilizers for curry leaf is applied in

   a) 4 doses b) 5 doses c) 3 doses d) 2 doses

II. Write whether the following sentences are True or False:

1. Curry leaf is a hardy crop.
2. DWR-2 variety of curry leaf is resistant to *Cylindrosporium* leaf spot.
3. Volatile oil and dehydrated curry leaves are the value-added products of curry leaf.
4. Fresh curry leaves contains 5 % of volatile oil.
5. Curry leaf is native to Terai region of Uttar Pradesh.

Answers

I

1. b
2. a
3. c
4. d
5. a

II 1. True

2. False
3. True
4. False
5. True

LECTURE 18

SAFFRON

Scientific Name : *Crocus sativus* Linn.
Family : *Iridaceae*
English name : Saffron
Indian name:*Keshara, Kunkuma, Aruna, Assa, Asrika* (Sanskrit)Zaffran, *Kesar* (Hindi), *Kungumapu* (Tamil) *Kunkumapuva* (Telugu), *Kunkuma Kesari* (Kannada) *Keshar* (Gujarathi), *Kesara, Keshar* (Marathi), *Jafran* (Bengali)

Saffron of commerce is the dried, tri-lobed stigmas of *Crocus sativus* Linn., a bulbous perennial plant. Saffron is one of the oldest and world's most expensive spices. The true saffron must not be confused with either meadow saffron *(Colchicum automnale* L., family *Liliaceae)* or safflower, or bastard saffron *(Carthamus tinctorius* L., family *Compositae),* which are occasionally used as adulterants.

The principal colouring agent of saffron is the glucoside `crocin' and the bitter substance is the glucoside `picrocrocin', besides which crocetin and safranal are the other main constituents. Saffron is very popular for its medicinal, flavouring and colouring properties. It is used abroad in exotic dishes, particularly in Spanish rice specialities and French fish preparations. It is also used in fine bread in many countries, viz., in Scandinavia as well as the Balkans.

In medicine, it is used occasionally in exanthematous diseases to promote eruptions. It is used in fevers, melancholia and enlargement of the liver and spleen. It also has stimulant and stomachic properties and is considered to be a remedy for catarrhal affections in children. In modern phamacopoeias, it is employed only to colour other medicines or as a cordial adjunct. Saffron has been employed as an abortifacient and several fatal cases have been recorded. Saffron bulbs are toxic to young animals, and the stigmas in large doses act as a narcotic.

Saffron is an important ingredient of both the *Ayurvedic* and *Unani* systems of

medicine in India. It is popularly known as a stimulant, warm and dry in action, helping in urinary, digestive and uterine troubles. It is mixed with other drugs to help in normal menstruation. If soaked overnight in water and used with honey, it facilitates micturation. Its oil is used as an external application in uterine sores. When pounded with *ghee*, it is reported to be very effective in controlling diabetes. It is also reported to strengthen the heart and brain, but only when administered in large doses. Saffron is also being investigated as an anti-cancer agent.

Saffron is an important food adjunct, i.e., food flavourant and food colourant and is also reputed to posses several medicinal properties. It is an important ingredient of Ayurvedic and Unani systems of medicine in India.

Origin and Distribution:

Saffron is a native of Southern Europe. It is cultivated in Spain, France, Italy, Austria, Greece, Iran, Turkey, Persia, England, India and China. The La-Macha belt of Spain is the largest producer of saffron in the world contributing to about 80-90% of the world's saffron production. In India, it is mostly cultivated in the Pampore and Kistwar areas of Jammu and Kashmir. Attempts have also been made to cultivate it in the Kinnaur area of Himachal Pradesh, the Kumaon and Garhwal regions of Uttar Pradesh and Arunachal Pradesh and the North-eastern region.

Area and Production:

No exact area and production is available, however, 27% of the saffron produced in India is exported to European and Middle East countries. India faces stiff competition from Iran, Spain, Greece and Morocco in the export trade.

Botany:

Saffron is a small bulbous perennial, 15-25 cm in height with an underground globular corm. Flowers are large, blue or lavender in colour. Plant is hysteranthous, with flowers arising directly from corms. Flowers have trifid or tri-lobed, orange coloured stigmas which, along with style tops, yield saffron of commerce.

Saffron yields an essential oil and fixed oil as high as 1.37 per cent and 13.4 per cent respectively. Saffron contains glycosides, crocin and picrocrocin together with lycopene, b-carotene, g-carotene and zeaxanthin. Crocin is the chief colouring principle in saffron. Chief flavouring component is safranal.

Climate

It is a temperate season crop and thrives well in cold regions. The plant can tolerate frost and snowfall easily; but during October-November the cultivated areas should be free

from snowfall. In the Kashmir valley, saffron thrives well in a sub-temperate climate at an elevation ranging from 1500-2400 m MSL. Sunny days during flowering are favourable for a good yield. An annual rainfall of 300 to 400 mm and snow during the winter are suitable for its commercial cultivation. Spring rains are favourable for the promotion of new corms, while a second spell of rains at the end of summer or at the beginning of autumn encourages profuse flowering. The number of flowers and time of blooming are dependent on the temperature prevalent in spring and autumn, and also upon the amount of rainfall. Dry and moderately humid weather conditions are conducive to early flowering. An optimum day temperature of 15 to 20°C is required during the flowering period with an optimum night temperature of 6 to 8°C. Frost or rain during flowering adversely affect the yield of the crop.

Soil

Saffron can be grown on different types of soils ranging from sandy loam to clay loam with good drainage. A medium-light soil, neutral to slightly alkaline, is suited for its cultivation. The clay-loam soil of the Kare area of the Kashmir valley, locally known as grut, is most suited for its successful cultivation. The corms tend to wrought in humid and water longed soils, hence, it should be avoided.

Varieties

SKU-S-86-KIS, SKU-S-86 WAT, SKU-S-86-QUIL, SKU-S-86-Sona, SKU-S-86 Lath, SKU-S-86 Chand, SKU-S-86 Chad are some of the indigenous and EC-37328, EC-221039, EC-217010, SKUAST, Nag C8708 and Badi C8606 are some of the exotic varieties available in this crop. The latter two exotic varieties have been found to give higher yield when compared with all the other local varieties.

Cultivation
Propagation

Plant is propagated vegetatively by using the underground corms. The corms selected for planting should be 2 to 5 cm in diameter. Each mother corm produces about 2 to 6 cormlets. Saffron undergoes deep dormancy from mid-June to August. The new cormlets produced annually remain attached to the mother corms till the beginning of the dormancy period.

Land preparation

The site is well prepared by ploughing 4-5 times to a depth of 30-35 cm during March-April. FYM @ 15-20 t/ha is incorporated into the soil during last ploughing. Strips of 2 m x 8 m, with 20 cm deep inter-drainage channels, are made. The channels are made around the beds to drain out the excess water. It is desirable to make raised beds in loamy soils.

Planting:

The planting season differs with the location. In the Kashmir valley, planting is done from mid-August to mid-September, whereas in Himachal Pradesh, planting is done from mid-July to mid-August. Well developed healthy corms are used for plating. The mean diameter of the seed corm should be more than 2.5 cm optimum corms size is 4-5 cm diameter. Corms should be treated with copper fungicide before planting.

The corms are planted in furrows at the rate of 30-40 q (500,000 corms) per hectare, at a depth of 7.5 to 10 cm, with a spacing of 5 to 7.5 cm between plants and 7.5 to 10 cm between rows. The corms are also planted at 12 and 18 cm or 15 and 20 cm apart in rows and at a distance of 10 cm in a row. Bigger corms gives more flowers and higher stigma yield.

Manures and fertilizers:

It is recommended to apply 15-20 tonnes of FYM /ha. and a fertilizer dose of 40 kg nitrogen and 50 kg phosphorus or NPK at 50:10:50 kg/ha for the commercial production of saffron. The usual practice in Himachal Pradesh is to apply 80-90 kg of nitrogen per hectare in 4-5 split doses at an interval of 20-25 days. Besides, it has been reported that 3-3.5% urea spray is effective in enhancing the total dry weight of saffron, but higher doses adversely affect the total dry yield of this crop.

Irrigation

In the absence of rainfall, irrigation is required during August-September during dry period. However, saffron should not be irrigated during the flowering season. Saffron is grown as an irrigated crop in Spain, while it is cultivated as a rain-fed crop in India.

Inter-culture

Fields should be kept weed-free for the proper growth and production of flowers. Weeding is done two to three times in a year to check the weed growth and also to avoid nutrient loss by weeds. Hoeing is also an important operation in the cultivation of saffron. The first hoeing should be done in the month of June, the second in the month of September and the third some time later.

Harvesting:

Plants flower in October-December. Blooming period and number of flowers depend upon weather conditions. Yield starts from the first year, but, economic yield is obtained from third year onwards. Flowers are collected daily, early in morning after dew disappears. Flowers are cleaned and style and stigma are separated from perianth. These operations require skilled labour and is usually done by women labourers. About 147,000 to 166,000 flowers give five kg of fresh stigma that go into make a kg of pure dry saffron. Yield of saffron in Kashmir is much lower than those in other countries (1.5 kg/ha). Production of saffron keeps increasing till 8^{th} year and starts declining thereafter and hence replanting is recommended after nine years.

Processed products

Value of saffron depends mainly on its colour, flavour and overall good quality which in turn depends on method by which stigma is dried. Tripartite stigmas plucked from freshly collected flowers and dried in sun constitute saffron of best quality. Stigmas are sundried to 8-12 % moisture. This constitutes first grade (Shahi saffron). Whole flowers are dried in sun for 3-5 days, beaten lightly with sticks, passed through coarse sieves. Material which passes through is then thrown into water; petals that float on water are thrown away and parts which sink are collected and dried. This forms second grade saffron (Mongra saffron). Discarded parts of flowers ani again subjected to beating process and process of throwing entire pounded mass in water is repeated. Product which sinks is collected, which is very much inferior in value thus constituting third grade (Lacha saffron). Alternatively, during bumper flower harvest, whole flowers are dried in sun and stigmas are picked late by hand from dried flowers.

In Spain, drying process is called ***I*** toasting', stigmas are placed over earthern kilns or pots containing low fire in sieves.

Final product as sold in market is a loosely matted mass of dark, reddish brown flattened stigmas with a characteristic aromatic odour and butter taste. When fresh, they are glossy and unctuous to touch, but after keeping they become dull and brittle. Dry stigmas are stored in cloth bags or butter paper and packed in closed tins or air tight wooden boxes. Present price of saffron is around Rs.50000/kg.

Yield

About 1,50,000 flowers are required to produce a kilogram of good-quality dried saffron. At the maximum stage of production, i.e., from the fourth year onwards, a farmer can get a yield of 2 to 2.5 kg/ha of Mongra-grade saffron in Jammu and Kashmir. However, in some countries the yield is as high as 12.5 kg/ha, particularly in Spain, depending on the crop management. Yields as high as 24.3 kg/ha have been reported from New Zealand. Generally, the yield will be highest between the third and the sixth year.

The final product as sold in the bazaar is a loosely-matted mass of dark, reddish-brown flattened stigmas with a characteristic aromatic odour and bitter taste. When fresh and dry they are glossy and unctuous (soapy or greasy) to the touch, but after keeping, they become dull and brittle.

Adulteration:

Because of high cost, saffron is frequently adulterated with the styles, anthers and parts of the saffron corolla. Exhausted saffron, flowers and floral parts of some plants belonging to the *composite* family, like *Calendula* sp. and Carthamus tinctorius, corn silk and various materials coloured with coal-tar dyes are also used as adulterants. Water, oil or glycerine are added to increase the weight. The cake saffron of commerce often contains safflower florets with adhesive sugary substances.

: REFERENCES :

1. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
2. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
3. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.

SAFFRON

I. **Write whether the following sentences are True or False:**

1. The product of commerce in saffron is the tri-lobed stigmas.
2. Pierocrocin is the chief colouring principle in saffron.
3. The chief flavouring component of vanilla is safranal.
4. The number of flowers and time of blooming is dependent on temperature and the amount of rainfall.
5. The drying process in saffron is called as U toasting in Spain.

II. Underline the correct answer in the following:

1. Saffron is propagated by using

   a) Corms b) Cuttings c) Seeds d) None of these

2. Saffron plants flower in

   a) October-December b) December-January c) March-April d) May-June

3. Saffron is a native of

   a) India b) Southern Europe c) Africa d) America

4. The first grade of saffron is called.

   a) Shahi saffron b) Mongra saffron c) Lacha saffron d) None of these

5. The number of flowers required to produce a kilogram of good quality dried saffron is

   a) 2,50,000 b) 1,50,000 c) 3,50,000 d) 1,00,000

Answers

I

1. True
2. False
3. True
4. True
5. False

II

1. a
2. a
3. b
4. a
5. b

THYME

Scientific Name : *Thymus uulgaris Linn.*

Family **:** *Lamiaca (Labiatae)*

English Name : Thyme
Indian Name : Banajwain (Hindi), Thyme (Kannada)

Thyme is one of the important European culinary herbs. Thyme is (Thymus uulgaris Linn.), commonly called 'Common Thyme' or 'Garden Thyme', yields red thyme oil of commerce. Dried leaves and floral tops constitute thyme of commerce known as ‘thyme herba’’. There are several other wild species which yield volatile oil are T *serpyllum* L., T *zygus* L. (white thyme) and T *satureioides* Coss and Bal. Thymol, linalool and linalyl acetate are the major compounds present in T.zygus and T *serpyllum. T zygus* and its var. *gracitis* are also the source for genuine thyme oil. While, thymol, burneol and a-terpineol are the major componds in T *satureioides,* the oil called the 'oil of thyme' in commerce is a colourless, yellow or red liquid, having a characteristic pleasant odour, and a pungent taste. The composition and also the quality of the oil is reported to vary in different geographical areas. The concentration of the active principle (Thymol) is high (60%) in Spanish oil and is low (20-35%) in French and Moroccon oils, whereas carvacrol is present in minor amounts.

The leaves and flowers used as food flavourants and in the seasoning of various food items, especially fish and meat preparations and for garnishing. Medicinally, the leaves are said to possess laxative, stomachic and tonic properties, good for the kidney and eye and are blood purifiers. The herb also has an insect-repellent property. It is also used in perfumery and in liquor distillery. The dried leaves and floral tops constituting the thyme of commerce, is known as Thymi Herba in pharmacy, which contains not more than 3% of stems over 1 mm in diameter and 2% of other organic matter and yields 4% acid insoluble ash. The shoot

extracts of flowering thyme plants have anti-bacterial action against *Micrococcus pyogenes* var. *aureus* and *Escherichia coil.* The herb, which has a pungent taste, is reported to possess antiseptic, antihelmintic, expectorant, carminative, diuretic, alexiteric, emmenogogue and sedative properties; it is good for liver complaints, pain in the spleen, liver or chest; it is useful in cold, asthma and bronchitis. It thins the phlegm and blood.

Thyme oil has antiseptic, antispasmodic and carminative properties. It is used in mouth-washes and gargles. Formulations containing thyme oil are available for the treatment of whooping cough and bronchitis. The oil is used as a diffusible stimulant in cases of collapse. It is mixed with olive oil and is used as a rubefacient and counter-irritant. It is also used in veterinary medicine. Thyme oil is used in soaps, perfumes and for flavouring food products such as meat, sausages, sauces and canned food. The oil has antifungal and antihelmintic properties and is used as an intestinal antiseptic in treating hookworms. It is also used as a cure for many fungal infections of the skin. The seeds are given as vermifuge. The infusion of the seeds is also used in skin eruptions or diseases. The seed oil has a potential use as a superior drying oil.

Origin and distribution:

Thyme grows wild in almost all the countries bordering the Mediterranean and also over much of Asia and in parts of Central Europe and grows the best in the hills. It is found in the Western temperate Himalayas, from Kashmir to Kumaon, between altitudes of 1,525 m and 4,000 m. Thyme is grown in Europe, Australia and North Asia. It is now cultivated in France, Germany, Spain, Italy, Greece and North Africa, Canada and the USA. In India, thyme may be cultivated in the Himalayas from Kashmir to Kumaon.

Area and Production:

The exact area and production of this crop is not available. Among the countries producing thyme oil, Spain stands first, followed by France, Morocco and the Mediterranean countries. The bulk of the world demand for this oil is met by Spain and Turkey.

Botany:

Thymus uulgaris is a low, evergreen, perennial under-shrub reaching a height of 20-30 cm. The roots are fairly robust and the stems are branched. The leaves are oblong-lancelolate, sessile with 10 mm x 3 mm size, with orange-brown, glandular dots, which are

coriaceous. The young leaves are slightly woolly. The flowers are small, purplish or bluish to almost white, united in spikes at the tip of the branches and have a bilabiate, tube-like calyx and a bilabiate, tubular corolla with a 3-lobed lower lip. The fruit is a nutlet, brown, 4-sectioned, smooth and is found in the remains of the calyx. The entire plant is aromatic. The cultivated Thyme yields about 2.5 % volatile oil whereas wild thyme yields 0.5 % oil.

Climate

The thyme flourishes well in warm climate, it can be grown both in the hills and the plains at an elevation of 1500-4000 m MSL. Hilly regions are best suited for its cultivation. However, the plants are susceptible to frost.

Soil

The crop prefers a light but fertile and calcareous soil for its good growth and oil content. On heavy, wet soils the aroma of the leaves is less and there are more chances that the plants may dry up soon.

Season

The seeds may be sown in nursery during April. Late summer is the time for transplanting the seedlings or planting rooted cuttings.

Cultivation

Propagation

Thyme can be propagated by seeds and vegetatively by the division of old plants or by cuttings or by layering of the side shoots in March or April.

The seeds are sown directly in rows or are sown in well-prepared nursery beds in good soils. Good soil is preferred for nursery, because the seedlings are very small and remain inconspicuous for several weeks after germination.

Land preparation

The land is prepared well by repeated ploughing or digging and brought to a fine tilth. Then, the land is divided into plots of convenient sizes.

Sowing/planting:

The seeds are sown directly in rows of 90 cm apart and after germination the seedlings may be thinned out to 30-45 cm within the row. While planting the seedlings or rooted cuttings or layers, they should be planted 30-45 cm in rows and 60 cm apart. A light irrigation is usually provided after planting.

Manures and fertilizers:

Application of FYM is done at the time of preparation of land. Fertilizers are applied @ 100:40:40 kg NPK/ha. A top-dressing of N and FYM in spring is reported to promote the formation of numerous leafy shoots.

Irrigation and Inter-culture.

The crop is planted late in summer it requires different irrigation during dry period. Inter-culture operations and weeding are done at regular intervals to encourage the good growth of the plants. In the hills, in order to avoid frost injury to plants during winter, mulching is done.

Harvesting and Processing:

The leaves and flowers, which are used for culinary and medicinal purposes, are harvested five months after sowing/ planting. The leaves and flowers are plucked from the plants or shoots of about 15 cm are cut off from the Plants, dried in the shade or in a dryer immediately after harvest and stored in air-tight containers to prevent the loss of flavour. The dried leaves are curled, are brownish-green in colour, and usually not longer than 6-7 mm. The dried shoots may also be powdered and packed. Under favourable conditions, the yield of dry herb is around 1,100-2200 kg/ha. The yield is comparatively low during the first year. The plants become woody, and their replanting becomes necessary after three or four years. For extracting the oil, the fresh herb is collected on dry days. The herb is collected at the stage when it just start flowering. At the time of collection, the lower portions of the stem, along with any yellow or brown leaves, need to be rejected.

Distillation of oil and oil yield

The oil is distilled from the fresh flowering tops by steam distillation. The herb contains about 2% essential oil and the oil recovered by distillation is about 21 kg/ha.

Value-added products

Volatile oil, oleoresin and thymol are the value-added products of thyme.

Thymol:

The chielf constitutent of the oil is thymol (about 45 %). In the pure state, thymol consists of colourless translucent crystals possessing an aromatic thyme like odour and a pungent taste. Thymol is also produced synthetically.

: REFERENCES :

1. Farroqui, A.A. and Sreeramu, B.S., 2005, Tropical Spice Crops and their cultivation, University Press, Hyderabad.
2. Farooqui, A.A. and Sreeramulu, B.S. 2001, cultivation of Thyme – a herb spice, *Spice India* 13 (2):19-21.
3. Farooqui, A.A. and Sreeramulu, B.S. 2001 cultivation of Medicinal and Aromatic plants, *University Press India Limited*, Hyderabad, India. PP 433-43.
4. Kumar, K., Abdulkhadar, Rangaswamy, P and Irrwlappom, 2010, I, Introduction to spices, Plantation crops, Medicinal and Aromatic plants. *Oxford and IBH Publishing Co.*, New Delhi.
5. Nybe, E.V., MINI RAJ. N. and PETER, K.V., 2007, Spices, Horticulture Science Series – 5 (Vol.5), *New Indian Publishing Agency*, Pitampura, New Delhi.
6. Package of practices of tree spices 1989, published by *Indian Institute of Spice Research*, Calicut.

THYME

Questions:

I. **Write whether the following sentences are True or False:**

1. Thyme is a deciduous perennial.
2. Thyme needs hot tropical climate for its growth and therefore, it cannot be grown on hills.
3. Thyme can be cultivated by seeds and also vegetatively.
4. Thyme belongs to the family Lamiaceae.

5. Essential oil is obtained from steam distillation of fresh flowering tops of thyme.

II. Multiple choices questions:

1. Thyme is common name for

a) *Thymus vulgaris* b) *Thymus zygus* c) *Thymus serpyllum* d) All of these

2. The shoot extracts of flowering thyme plants have anti-bacterial action against.

a) *Micrococcus pyogenes* var. *aureus* b) *Escherichia coil* c) both a and b

d) None of these

3. The wilt disease in thyme can be controlled by spraying.

a) Dithane M-45 b) Rogor c) Basalin d) 2, 4-D

4. Ideal spacing for thyme cultivation is

a) 1.5 m x 50 cm b) 90 cm x 90 cm c) 1.5 m x 1 m d) 60 cm x 40 cm

5. Aromatic part of thyme plant.

a) Leaves only b) Flowers only c) Fruit only d) The whole plant

Answers

I

1	False
2	False
3	True
4	True
5	True

II

1	d
2	c
3	a
4	d
5	d


****thanks ****


****all the best ****