NRCS

SPICES PRODUCTION TECHNOLOGY

A Compendium of Lectures

भाकृअनुप
ICAR

NATIONAL RESEARCH CENTRE FOR SPICES
MARIKKUNNU P.O., CALICUT-673 012
KERALA

SPICES PRODUCTION TECHNOLOGY

A Compendium of Lectures

Training Programme for
Central and State Government Officials

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SPICES RESEARCH AND DEVELOPMENT - AN OVERVIEW

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Production of spices in India during 1991-92, showed increase in black pepper, cardamom, ginger, turmeric, cumin, fennel, fenugreek and tree spices. Reduction was recorded in chilli and coriander (Table 1).

Table 1. Production of spices in India during 1990-91 and 1991-92('000 t)

Spices	1990-91	1991-92	% Increase/ decrease
Pepper	48.98	57	16.37
Cardamom	4.75	5	5.26
Ginger	148.52	156	5.04
Turmeric	347.80	349	0.35
Chilli	691.00	617	-10.71
Coriander	211.50	148	-30.02
Cumin	71.80	80	11.42
Fennel	17.80	18	1.12
Fenugreek	33.70	35	3.86
Clove	1.38	1.5	8.70
Nutmeg	1.06	3.2	201.89
Cinnamon	-	0.3	-

Export of spices during 1992-93 showed a decrease (-6%) in quantity and value in dollar terms (-12%), though in rupee terms, there was increase by 6% (Rs. 382 crores) (Table 2).

Table 2. Export of spices from India during 1992-93 and % change over 1991-92.

Spices	1992-1993		(%) change over 1991-92	
	Quantity (t)	Value (Rs.Lakhs)	Quantity	Value
Black pepper	25480	8317.35	24	12
Cardamom (Small)	175	679.59	-68	-58
Cardamom (Large)	1270	807.85	36	70
Chilli	16850	6786.56	-50	-31
Ginger	8220	1569.62	-39	-23
Turmeric	18950	4631.65	14	47
Coriander	13550	1991.48	47	67
Cumin	2080	1176.95	42	100
Celery	2750	418.30	-1	-10
Fennel	2650	635.80	59	75
Fenugreek	4850	521.20	-2	23
Other seed spices	1000	206.95	-25	-26
Garlic	7700	716.98	-22	-6
Other spices	13700	2166.00	42	84
Curry Powder	2900	1040.95	-5	20
Spice Oils and Oleoresins	1140	6539.23	1	17
Total	123265	38206.45	-6	6

Export increased in value terms in pepper (12%), large cardamom (70%), turmeric (47%), coriander (67%), cumin (100%), fennel (75%), fenugreek (23%), other spices (84%), curry powder (20%) and spices oils and oleoresins (17%) over 1991-92 export figures. There was reduction in export of small cardamom, chilli, ginger, celery, other seed spices and garlic. Only 82% of the export target in quantity and 90% in value were realised during 1992-93 (Table 3).

Table 3. (%) achievement of target in export of Spices during 1992-93.

Spices	% achievement of target	
	Quantity	Value
Black pepper	80	74
Cardamom (Small)	44	57
Cardamom (Large)	127	135
Chilli	60	79
Ginger	69	78
Turmeric	120	132
Coriander	118	159
Cumin	104	147
Celery	92	76
Fennel	133	127
Fenugreek	88	130
Other seed spices	50	52
Garlic	77	90
Other spices	69	66
Curry Powder	83	104
Spices Oils & Oleoresins	88	101
Total	82	90

Increasing trend in the export of spice oils and oleoresins continued this year also. World trade in spices in 1992-93 was 4.5 lakhs tonnes valued US $ 1,500 million and India's share was 1.23 lakhs tonnes (27%) valued US $ 131 million (9%) (Table 4).

Table 4. Vital statistics on spices

World trade in spices in 1992-93.	4.5 lakh tonnes valued US $ 1,500 million.
India's export in 1992-93	1.23 lakh tonnes valued 131 million US $(Rs.382.06 crores)

Projected world trade in spices in 2001	6.25 lakh tonnes valued US $ 2200 million to US $ 3000 million.
Projected India's export in 2001.	2.0 lakh tonnes valued US $ 550 million.

Export target of spices during 1993-94 is 1.5 lakh tonnes valued Rs. 500 crores (Table 5).

Table 5. Export target of spices for 1993-94.

Spices	Quantity (t)	Value (Rs. crores)
Black pepper	30000	105.00
Cardamom (Small)	350	11.00
Cardamom (Large)	1300	8.50
Chilli	25000	80.00
Ginger	10000	18.00
Turmeric	20000	40.00
Coriander	12000	16.00
Cumin	2500	13.00
Celery	3000	5.00
Fennel	3000	6.00
Fenugreek	5000	5.00
Other seed spices	1350	3.00
Garlic	10000	10.00
Other spices	21000	32.00
Curry Powder	3500	17.50
Spices oils & oleoresins	2000	130.00
Total	150000	500.00

Policy to boost production and export :

Spices districts, Small Farmers Agri Business Consortium, Indian Spices Logo and Brand Promotion, Market Intervention and

Special Subsidies may boost up production during 1993-94 (Table 6). The VIII Plan targets a growth rate of 10% in spices production compared to 4% in VII Plan. Investment on spices production under central sector scheme was only Rs. 5.74 crores during 1991-92 and it is now Rs.150 crores during 1992-1997(VIII Plan). There is alround enthusiasm for spices production in the country.

Table 6. Major policy decisions which may boost up production and export of spices.

	Policy decisions	Impact
1.	Spices districts (Wynad and Idukki in Kerala)	Single window system for production and marketing. Concerted R,D&E efforts on selected districts.
2.	Small Farmers' Agri-Business Consortium (SFABC)	Production,value addition,quality maintenance and marketing on co-operative basis. One district in each state.
3.	Indian Spices Logo and Brand Promotion	Maintenance and assurance on quality of Indian spices through standards and specifications.
4.	Market intervention	To maintain prices of spices from crushing down.
5.	Special subsidies	Promotion of export by bringing local price at par or below international price.

Research attainments :

Considerable increase in productivity has been reported in research stations especially in pepper, ginger, turmeric and coriander(Table 7). The need is effective transfer of technology. Attempts are made to identify main production constraints and workout appropriate and economic strategies (Table 8).

Table 7. Potential for productivity increase at the national level.

Crop	National	Progressive farmer	Research station	Abroad
Pepper	290	2000	2445	2925 (Malaysia)
Cardamom	75	1625	450	200 (Guatemala)
Ginger	2421	5500	8250	--
Turmeric	2738	6200	10700	--
Coriander	476	--	1900	515 (Morocco)
Cumin	578	--	2000	--

Table 8. Main production constraints in spices.

Spices	Constraints	Research attainments
Black pepper	Phytophthora foot rot	Management of the disease through a package of practices is standardised. Tolerant lines to the disease are developed.
	Stunted disease	No effective control measures except uprooting of diseased plants.
	Slow decline	Effective management method(s) are available except no source of resistance to Radopholus similis nematode.
	Low productivity	High Production Technology (HPT) is demonstrated.
Small Cardamom	'Katte' disease	Virus etiology is established. 'Katte' escapes are identified.
	'Vein clearing virus disease'or 'Kokke kanthu'.	Removal of diseased plants is advocated.No effective management measures are available.
	Low productivity	High Production Technology (HPT) is demonstrated.

Ginger and Turmeric	Rhizome rot	Causative organisms are identified. Solarization of soil prior to planting is effective.
	Bacterial wilt	Pseudomonas solanacearum is the causal organism. No resistant variety available.

So far, 8 high yielding varieties/hybrids in black pepper, 5 in small cardamom, 3 in ginger, 12 in turmeric, 11 in coriander, 3 in cumin, 4 each in fennel and fenugreek are released (Table 9).

Table 9. High yielding spices varieties released.

Spices	Hybrids (H) and Varieties (V) released
Black pepper	Panniyur 1 (H), Panniyur 2 (V), Panniyur 3 (H), Panniyur 4 (V), Subhakara (V), Sreekara (V), Panchami (V), Pournami (V).
Cardamom	Mudigere (V), Pv.1 (V), CCS-1 (V), ICRI.1 (V), ICRI.2 (V).
Ginger	Suprabha (V), Suruchi (V), Suravi (V).
Turmeric	Co.1 (m), Krishna (V), Sugandham (V), BSR.1 (V), Suvarna (V), Roma (V), Suroma (V), Rajendra Sonia (V), Suguna (V), Sudarshana (V), Ranga (V), Rasmi (V).
Coriander	Co.1 (V), Co.2 (V), Gujarat Coriander 2 (V), Rajendra Swati (V), RCr.4 (V), Sadhana (V), Swathi (V), Co.3 (V), CS.287 (V), Sindhu (V), UD 20 (V).
Cumin	S.404 (V), MC.43 (V), Gujarat Cumin. 2 (V).
Fennel	S.7-9 (V), PF.35 (V), Gujarat Fennel.1 (V), Co.1 (V).
Fenugreek	Co.1 (V), Rajendra Kanti (V), RMt.1 (V), Lam Selection.1 (V).

An exclusive nucleus seed multiplication programme to supply quality planting materials to farmers is under implementation. Research results are available on rapid multiplication of black pepper, cardamom, clove, nutmeg, cinnamon, ginger and turmeric (Table 10). Biotechnological research has great potential in spices (Table 11).

Table 10. Methods of plant propagation in spices

Spices	Method of propagation	Advantages
Black pepper	Single nodded rooted cuttings using bamboo method	Multiplication rate of 1:40 per year. Good anchorage due to presence of two root systems.
Cardamom	Trench method of sucker production	Multiplication rate of 1:20 per year.
Clove	Inarching on clove seedlings	Earliness, dwarfness and high productivity.
Nutmeg	Epicotyl grafting	Female plants are propagated.
	Top working	Conversion of male plants to female plants.
Cinnamon	Cuttage	Rapid multiplication of elite plants.
Ginger and Turmeric	Crop rotation, solarisation and disease free rhizomes.	Management of rhizome rot.

Table 11. Potential applications of plant biotechnology in spices.

1) Micropropagation and rapid clonal multiplication of high yielding elite genotypes to generate adequate good quality and disease free planting materials.

2) Exploiting somaclonal variation and utilisation of techniques like somatic cell hybridization, anther culture, embryo rescue etc. for crop improvement.

3) *In vitro* selection for resistance to biotic and abiotic stresses.

4) *In vitro* conservation and safe exchange of germplasm, and

5) Production of flavour and volatile constituents in culture.

Salient achievements in biotechnology in spices include micropropagation and clonal multiplication in cardamom, black pepper, ginger, turmeric, cinnamon and vanilla (Table 12). *In vitro* selection for resistance to biotic and abiotic stresses especially rhizome rot in ginger is in progress.

Table 12. Salient achievements in biotechnology in spices.

Spices	Achievements
Cardamom	Clonal multiplication, Field evaluation of tissue cultured plants, Inflorescence culture, Regeneration of plantlets from callus.
Black pepper	Clonal multiplication, Callus culture and regeneration of plantlets, Micropropagation of related species of *Piper*.
Ginger	Clonal multiplication, Field evaluation of TC plants, *In vitro* rhizome formation, Regeneration of plantlets from callus, *In vitro* selection, *In vitro* polyploidy, Inflorescence culture and *In vitro* development of fruit.
Turmeric	Micropropagation, Plant regeneration from callus, Micropropagation of related species and genera.
Tree spices	Micropropagation, *In vitro* proliferation of mace and synthesis of flavour components in culture.
Vanilla	Seed and embryo culture.

Quality maintenance in Indian spices :

India has a global monopoly in spices oils and oleoresins. During 1992-93, India exported 1140 tonnes of oils and oleoresins valued Rs. 65.39 crores against 1132 tonnes valued Rs. 56.03 crores during 1991-92. There are AGMARK specifications for

various Indian spices and their value added products. The Bureau of Indian Standards has published a series of specifications to maintain and improve quality of Indian spices (Table 13). High curcumin lines in turmeric, high piperine lines in black pepper, high essential oil lines in clove, cinnamon and nutmeg etc. are in the pipeline at National Research Centre for Spices, Calicut.

Table 13. Role of Bureau of Indian Standards to improve quality of Indian Spices.

Standards approved and circulated	Details
Spices and Condiments Sectional Committee FAD.9 deliberated and approved several standards.	IS 4404:1992 on Cloves, IS 13474: 1992 on Green Pepper; IS 13545:1992 on Garam Masala; IS 13446:1992 on Large Cardamom etc.

Environmentally friendly spices culture :

Use of plant protection chemicals leads to residual toxicity in spices products. Moreover, there is high premium for organic spices. Biocontrol of pests and diseases is another area where useful information are generated (Table 14). A fungus Trichoderma sp. in combination with VAM suppresses Phytophthora capsici, causative organism of foot rot in black pepper. Biopesticides to manage pests of spices are also developed.

Table 14. Bio-control of pests and diseases in spices.

Spices	Pests/diseases	Biocontrol agent tried
Black pepper	Phytophthora capsici	Trichoderma sp. in combination with VAM.
	Scale insects	Natural enemies viz., Encarsia lounsburyi.
	Top shoot borer	Apanteles cypris, an important parasite.

	Pollu beetle	An entomophagous mite and nematode
Cardamom	Rhizome rot and damping off	Trichoderma sp. and Paecilomyces lilacinus
	Root-knot nematode	Paecilomyces lilacinus

The targetted export during 1993-94 is 1.5 lakh tonnes valued Rs. 500 crores. Research and development activities are well tuned to achieve the above targets. The year 1992-93 also witnessed fall in export of cardamom, hike in cardamom prices, political disturbances in the then USSR, the main buyer of pepper, high production of chillies in Bangladesh sufficient to meet their requirements, the domestic political disturbances, frequent and prolonged port strikes etc. The targetted production and export of spices oduring 1993-94 would be achieved subject to the stability in remunerative prices and the extent to which above negative trends are reversed.

NATIONAL RESEARCH CENTRE FOR SPICES (ICAR)
KOZHIKODE - 673 012
Priced Publications

1.Spices Varieties - Rs.125 per copy + Rs.25 postage charges

2.Diseases of Black Pepper - Rs.300 per copy + Rs.25 postage charges

Payment to be made in favour of ICAR - Unit, NRCS, CALICUT through Demand Draft.

exocarp turns red when ripe. Embryo is minute. Ripe seeds germinate in 35-50 days. Cultivated types have a somatic chromosome number of 2n = 52.

Floral biology:

Cultivated pepper is mostly hermophrodite, while the wild species are mostly dioecious. In the cultivated types, instead of the usual bisexual flowers, male or female flowers occassionally arise, the percentage of which may vary.

Table 1. Spike composition of pepper cultivars

Cultivars	(%) of flowers		
	Bisexual	Female	Male
Kalluvally	80.0	14.0	6.0
Balancotta	90.0	7.0	3.0
Uthirancotta	2.0	88.0	10.0
Kumbakodi	93.0	--	7.0
Karimunda	98.0	2.0	--
Narayakkodi	98.0	0.5	--
Kalluvally (Type 2)	99.6	0.1	0.3
Panniyur-1	97.2	2.8	--

The flowers in most cases are protogynous - the female phase maturing first and then the male phase. This interval between male and female phases varies from 0-15 days or even more. The stigma remains receptive for about 3-5 days. Pollen grains are small, and can remain viable in water for about 3 days. The phenomenon of protogyny is made use of in crossing work.

Pepper is naturally self pollinated in spite of the existence of protogynous condition. The anther dehisces in the evening. The gravitational descending of the pollen grains leads to the pollination of the flowers down below. Pollination is aided by dew drops or water droplets. Variation in pollen

BOTANY AND CROP IMPROVEMENT OF BLACK PEPPER
(PIPER NIGRUM L.)

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Origin and distribution:

Genus Piper is a native of the humid tropics. The centre of diversity for black pepper is the Western Ghat forests of South India. Pepper was under cultivation from ancient times and many cultivars got evolved through domestication.

Pepper is a perennial glabrous woody climber, propagated by stem cuttings. It climbs on support trees by means of adventitious roots produced at the nodes. It has a dimorphic branching system: the upward growing shoot - orthotropic shoot is monopodial in growth and lateral fruiting branches - plagiotropic shoots which has sympodial mode of growth. The spike is leaf-opposed and is the modified terminal bud; the growth is further continued by the axillary bud.

Leaves are simple, alternate and variable in size and to some extend in shape also. Considerable variation exists among various cultivars.

Pepper plants usually start flowering by the second or third year after planting. Flowers are borne on independent spikes, which vary in length from 3-20 cm among cultivars. Flowers are mostly hermaphrodite, small, borne on axils of fleshy bracts, perianth absent, stamens two, small on either side of the ovary, anthers small with 2 sacs, ovary globose, 1-celled and 1-ovuled. Fruit is sessile globose drupe (often called as berry). The

fertility and insufficient pollen availability are perhaps the main cause of poor spike setting.

Controlled crossing is carried out in specially planted crossing blocks where lateral shoots are rooted and maintained in pots. Protogynous condition is made use of in the pollination work. Spikes are bagged and when stigma becomes receptive they appear white and glistening. Pollination is carried out by applying a pollen suspension in water by means of a soft brush. For this, mature anthers are collected in the afternoon in a small vial and kept in a desicator. Next day morning, they are crushed and mixed with a few drops of water to get a suspension of pollen grains. The pollination process is repeated daily till anther emergence is noticed when the pollination is stopped and the unpollinated part of the spike is cut off to avoid chances of selfing.

Crop improvement:

Objectives:
1. Improvement in yield and quality
2. Resistance to Phytophthora foot rot
3. Resistance to nematode and Pollu beetle
4. Evolving drought tolerant types
5. Evolving shade tolerant types suitable for interplanting in coffee, cardamom, coconut and arecanut plantations.

In order to achieve above aims, a series of crop improvement programmes are initiated at NRCS.

1. Germplasm collection and evaluation:

This is the primary step in the improvement of any plant. Cultivated types of pepper were collected from all the pepper growing areas and are being evaluated for yield and disease resistance. Wild germplasm collections are also being carried out for future use in crop improvement. At present, the germplasm

collection of NRCS consists of over 600 collections of cultivated popper vines.

2. Selection in established cultivars:

To evolve high yielding stable, uniform lines, selection programmes are initiated in Karimunda and Kottanadan which are the most popular cultivars (apart from the hybrid Panniyur-1). A large number of elite lines were collected in these two cultivars, multiplied and planted for yield evaluation. From the first batch of 100 elite Karimunda lines, two high yielding lines were selected - 'Sreekara' and 'Subhakara'- out of which one (Subhakara) was officially released. These gave yield of over 4 kg consistently for the first three years.

Evaluation of promising cultivars led to selection of two other high yielding lines namely Aimpiriyan (856) and Ottaplackal-1(812). The second one is relatively tolerant to root knot nematode. One line was released from the Pepper Research Station, Panniyur, Viz., Panniyur-4, a selection from Kuthiravally.

Table 2. Yield and quality attributes of improved pepper cultivars

Cultivars	Yield (dry-kg/ha)	Potential Yield (dry-kg/ha)	Piperine (%)	Oil (%)	Oleoresin (%)
'Sreekara'	2677	4200	5.1	7.0	13.0
'Subhakara'	2352	4487	3.4	6.0	12.4
'Aimpiriyan' '856'(Panchami)	2828	6528	4.7	3.4	12.5
Ottaplackal-1 (Pournami)	2333	5356	4.1	3.4	13.8
Panniyur-1	1242	--	5.2	3.3	11.8
Panniyur-2	2570	3313	6.5	3.4	12.2
Panniyur-3	1953	3269	4.8	3.1	10.4
Panniyur-4	1277	2443	4.4	3.1	11.3
Panniyur-5	1098	2587	5.3	3.8	12.3

3. Production and screening of hybrids:

A large number of intercultivar hybrids are produced and screened for yield and disease resistance. The hybrids are produced in many combinations.

At the Pepper Research Station Panniyur, a hybrid variety was developed (Panniyur-1), a hybrid between Uthirankotta and Cheriakaniakkadan in the late 1960s. During the last two years five lines were released from this station, which include Panniyur-3, again a hybrid between Uthirankotta and Cheriakaniakkadan.

4. Screening for Phytophthora and nematode tolerance:

All the germplasm materials, intercultivar hybrid lines, open pollinated progenies etc., were all screened for locating tolerance/resistance to Phytophthora and nematodes. Phytophthora capsici is the causal organism of the foot rot disease. The pepper yellowing (slow decline) is a complex disease where both the nematode Radopholus similis and Phytophthora play critical roles.

A few cultivars and hybrids relatively tolerant to Phytophthora and one line tolerant to nematode are now under yield evaluation.

5. Screening of open pollinated progenies:

To exploit, the locked up variability, populations of OP seedlings were planted in the field for yield and quality evaluation. From this, a few selections were made based on yield and are being evaluated at NRCS. Panniyur-2 and Panniyur-5 are selection from open pollinated progenies of Balankotta and Perumkodi respectively.

6. Biotechnological approaches

Recently tissue culture techniques are bieng developed in black pepper. It may be possible to induce somaclonal variations and they may be of considerable use in generating variability in peper. Transfer of resistance gene from the resistant species *P. colubrinum* through genetic engineering is being tried for creating black pepper resistant to foot rot and nematode.

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BOTANY AND CROP IMPROVEMENT OF GINGER, TURMERIC & VANILLA

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I. GINGER

Ginger is an important spice produced and exported from India. The crop is cultivated in an area of 14040 ha in Kerala with a total production of 44500 tonnes. The other important ginger producing states are Orissa, West Bengal, Andhra Pradesh, Karnataka and Tamil Nadu. Ginger of commerce is the dried rhizome of Zingiber officinale. The crop is presumed to be originated in South East Asian region.

Morphology:

Ginger is a monocotyledonous, slender, perennial herb, usually grown as annual, 30-100 cm tall with a robust branched rhizome borne horizontally near surface of soil, bearing leafy shoots close together. The shoot, leaf and stem emit pleasant aroma.

Fleshy, sympodial rhizome is hard, thick, somewhat laterally compressed, about 11.5 - 2.5 cm in diameter and usually pale yellow or black within. It is covered with small scales and with fine fibrous roots in top layer of soil. The anchorage roots are succulent and when squeezed exude appreciable fluid and emit aroma similar to the one from other plant parts.

Inflorescence:

The inflorescence arises directly from root stock and is spicate, 15-25 cm long. The spike is cylindrical, cone-like, 4-7 cm long and 1.5 - 2.5 cm in diameter. The bracts are appressed,

ovate or eliptical, 2-3 cm long, 1.5 - 2.0 cm vide. One or two flowers are produced from the axil of each bract.

Table 1. Improved cultivars of ginger released for cultivation

Name	Centre of Release	Average yield (fresh) (t/ha)	Potential yield (fresh) (t/ha)	Maturity (days)	Dry recovery (%)	Crude fibre (%)	Oleo-resin (%)	E.Oil (%)
Suprabha	HARS Orissa (OUAT) POttangi	16.6	22.8	229	20.5	4.4	8.9	1.9
Suruchi	"	11.6	21.8	218	23.5	3.8	10.0	2.0
Suravi	"	17.5	21.6	225	23.0	4.0	10.2	2.1

Cultivars

Several commercial types of ginger are cultivated. They are generally known after the localities or place from where they are collected or cultivated. Some of the more important indigenous types are Maran, Kuruppampadi, Thodupuzha local, Wynad local, Bajpai, Himachal, Nadia etc. Rio-de-Janeiro, Tafin Giwa, Jamaica, China etc., are some important exotic cultivars. Suprabha, Suruchi and Suravi are three high yielding selections from OUAT, Pottangi (Orissa). These cultivars yield 16.6, 11.6 and 17.5 t/ha fresh ginger, respectively (Table 1).

Crop improvement

The chromosome number of cultivated ginger (Z. officinale) is 2n=22. Crop improvement work by polyploidy breeding is in progress at NRCS, Kozhikode. One tetraploid line (2n=44) of cv 'Maran' is undergoing field evaluation at two locations and another tetraploid line of cv 'Manatodi' is under initial evaluation at NRCS, Kozhikode.

Another aspect of crop improvement of ginger is through collection of cultivated germplasm from ginger growing areas, their characterisation and comparative yield evaluation. Based on yield and quality evaluation, cultivars with high yield potential (Maran, Karakkal, Sargigudda, Santhing laidum, Rio-de-Janeiro, Himachal, PGS-37, PGS-39), high dry recovery (Karakkal, Nadia, Maran, Kuruppampadi local, S-557, Assam, Ernad Chernad, Thing pui, Zahirabad etc.), high oleoresin (Ernad - Chernad, China, Kuruppampadi, Rio-de-Janeiro), high oil, (Narasapattam, Himachal, Maran, Nadia, Ernad Chernad) and less fibre (Jamaica, Bangok, China) were identified. CUltivars like Maran, Nadia and Bajpai are suitable for cultivation in plains of Kerala. Cultivar 'Suravi' is obtained through mutation breeding.

Crop improvement through hybridisation is handicapped by absence of viable seed set. Studies conducted at the National Root Crops Research Institute, Umudike, Umuhia, Nigeria showed that seed set is possible by hybridisation. Fruit set has been achieved from pollination of stigmas of both the protruding 'pin type' and the hidden 'thrum type' styles but significantly more from the later. However, seeds were not viable. Another observation on seed set in ginger cultivars indicates that by planting large size setts (30 g), profuse flowering and good seed set can be obtained.

Studies have also proved that plant height is an important factor determining rhizome yield of ginger. Leaf length is also another important yield contributing trait. Optimum number of tillers are desirable in high yielding cultivars.

None of the available cultivars studied so far showed tolerance/resistance to soft rot and bacterial wilt diseases, the major production constraints of ginger in Kerala, at present. However, all the available 360 odd germplasm at NRCS, Kozhikode are being screened for resistance against these problems. Another major disease of ginger is leaf spot caused by Phyllosticta zingiberi. Preliminary screening of the germplasm under field conditions indicates certain degree of tolerance against this melody by few cultivars and detailed studies are being done. Somaclonal variation through crop improvement and in vitro screening of somaclones and

cell lines can be exploited further in developing high yielding disease resistant cultivars. Work on this line is in progress at NRCS, Kozhikode.

II. TURMERIC

Turmeric (Curcuma longa L. syn. C. domestica) is a major rhizomatous spice produced and exported from India. It is used as a condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. The genus Curcuma belongs to the family Zingiberaceae. It is thought to be originated in South East Asia. C. aromatica (Kasturi type) has got a characteristic aromatic flavour and it is mainly used in cosmetic industry. C. amada (mango ginger) is used as a vegetable.

Andhra Pradesh ranks first in terms of area (46,300 ha) and production (1,44,700 t) of turmeric followed by Orissa and Tamil Nadu. In Kerala, the crop is grown in about 3,000 ha with a total production of 5,900 tonnes.

Morphology

Turmeric is an erect, perennial herb being grown as an annual crop. The primary tubers at the base of aerial stem is ellipsoidal, bearing many rhizomes, straight or slightly cruved with secondary and sometimes teritiary fingers, the whole forming a compact clump. Rhizomes have distinctive taste and smell. They are orangish brown or pale purple outside and bright orange or blue black inside, when fresh.

The leafy shoots are around 1 m in height and are erect bearing 6-10 leaves with the leaf sheaths forming a pseudostem. Inflorescence is a cylindrical spike. The bracts are adnate for less than half their length and are elliptic, lanceolate and acute, 5-6 cm long and about 2-5 cm wide. The upper bracts are white or whitish streaky with green pink tip in a few cultivars leading to light green bracts lower down. Flowers are borne in the axils of the bract, opening one at a time. The calyx is short, usually toothed and split

Table 2. Improved cultivars of Turmeric released for general cultivation

Name	Centre of Release	Average (fresh) (t/ha)	Potential yield (fresh) (t/ha)	Duration (days)	Dry recovery (%)	Curcumin (%)	Oleoresin (%)	Essen. Oil (%)	Special Features
Co-1	TNAU Coimbatore	30.0	35.0	285	19.5	3.2	6.7	3.2	Suitable for drought-prone areas as well as saline and alkali soils
Krishna	Maharashtra Agri. University	9.2	11.8	240	16.4	2.8	3.8	2.0	Tolerant to leaf diseases
Sugandham	Kasba Digraj Gujarat Agri. University, Jagudan	15.0	20.0	210	23.3	3.1	11.0	2.7	"
BSR-1	TNAU, Coimbatore	30.7	39.6	285	20.5	4.2	4.0	3.7	Suitable for drought prone areas
Suvarna (PCT-8)	NRCS, Kozhikode	17.4	43.5	200	20.0	4.3	13.5	7.0	Short duration
Suguna (PCT-13)	NRCS, Kozhikode	29.3	60.3	190	12.0	7.3	13.5	6.0	"
Sudharsana (PCT-14)	NRCS, Kozhikode	28.8	54.9	190	12.0	5.3	15.0	7.0	"
Roma	HARA, Orissa (OUAT) Pottangi	20.7	40.0	250	31.0	9.3*	13.2	4.2	--
Suruchi	HARA, Orissa (OUAT) Pottangi	20,0	44.9	253	26.0	9.3*	13.1	4.4	--
Rajendra Sonia(RH-10)	Rajendra Agri. University, Dholi	4.8	--	225	18.0	8.4	--	5.0	Resistant to leaf blotch
Ranga	HARS, Orissa (OUAT) Pottangi	29.0	37.1	250	24.8	6.3	13.5	4.4	--
Rasmi	HARS, Orissa (OUAT) Pottangi	31.3	37.5	240	23.0	6.4	13.4	4.4	--

Provisional *

nearly half down on one side. The corolla is tubular at the base with upper half cup shaped with 3 unequal lobes inserted on the edge of the cup lip. It is whitsh, thin with dorsal lobes hooded. There are 2 lateral staminodes. The filament of the stamens is short, broad, trilocular with a slender style passing between anthers and held by them.

Crop improvement

C. longa is considered to be triploid with a somatic chromosome number of sixtythree (2n = 3x = 63). However, 2n = 64 is also reported. C. aromatica is a tetraploid (2n = 4x = 84).

About 50 commercial cultivars of turmeric are recognised in the country and are known after the name of the locality of their cultivation. N.R.C.S. Kozhikode, has got more than 350 cultivars. Some of the pepper cultivars are Duggirala, Tekurpet, sugandham, Amalapuram, Alleppey, Moovattupuzha, Rajpuri, Juggigan, Mydkur and G.S Puram. Based on duration of maturity, turmeric cultivars are classified as short duration Ca types, (7 months) eg. Kasturi, medium duration Cli types (8 months) eg. Kothapeta and long duration Cll types (9 months) eg. Duggirala, Tekurpetta, Mydkur, Armoor.

Crop improvement in turmeric by selection and mutation breeding resulted in many high yielding cultivars. Suvarna, Suguna and Sudharsana are improved selections from NRCS, Koshikode (Table 2).Co-1 and BSR-1 are mutants of Erode local variety of turmeric released by TNAU, Coimbatore. Edapalayam, Thodupuzha, Wynad local, Idukki No.2 Cll-328, Sugandham, Palappally, Manantody etc., are turmeric cultivars having high curcumin content (about 9-10%) while Kahikuchi and Kasturi are high in volatile oil content and Konni as well as Amrithapani are high oleoresin containing types.

Studies have proved that plant height, number of primary fingers and tillers had good correlations with rhizome yield.

Seed set is observed in turmeric. However, good seed setting is not observed in all the cultivars. Turmeric seeds are brownish black in colour, and more or less of the same size and shape of

Acasia seed. Seed viability is low. Hence seeds need to be sown immediately after collection. Seed setting in the clonally propagated crop has opened up new vistas in crop improvement of turmeric. Already seven progeny lines are undergoing advanced yield evaluation trials at N.R.C.S. Hybridization between different cultivars is also being attempted to evolve high yielding, good quality, disease resistant cultivars.

III VANILLA

Introduction

Natural vanillin is extracted from the dried and cured pod like fruits known as 'beans' of vanilla plant. Vanilla, a native orchid of Mexico, was introduced to India as early as 1835. The important vanilla growing countries are Madagascar, Java, Mauritius, Tahiti, Seychelles, Zanzibar, Brazil, Jamaica, Guatemala, Reunion Islands and West Indies. At present, Madagascar accounts for 80% if the world production of vanilla beans. The estimated area under vanilla in India is only about 30 acres, largely confined to Wynad and Nilgiri districts of Kerala and Tamil Nadu, respectively.

There are three important species of vanilla viz. Vanilla fragrans Salisb, syn., V. planifolia Andr. (the Mexican vanilla), Vanilla pompona Sch. (the West Indian Vanilla) and Vanilla tahitensis J.W. Moore (the Tahitian vanilla). V. pompona has large and broad leaves as well as fleshy large flowers as compared to V. fragrans. The petals and sepals of V. pompona is greenish yellow with bright green colour at the tips whereas the petals and sepals of V. fragrans are pale green. Vanilla fragrans also have short, thick and obscurely three angled pods. V. tahitensis is less robust than V. fragrans and this species is predominantly cultivated in Hawaii. All the three species are diploid ($2n = 32$).

Vanilla is a climbing orchid having sessile leaves, oblong in shape with succulant green stems. At the nodes aerial roots (velamen roots) are produced. Flowers appear in racemo which are large and showy, borne on 4-5 cm long stalks. The inflorescence consisists of 15-20 flowers produced in leaf axils. There are three sepals and petals each. There is a central column in the flower in which stamens and pistil are united with one of the petals modified to form a 'lip' or 'rostellum'.

Climate and soil

Vanilla requires a humid tropical climate with an annual rainfall of about 250 cm and grows from almost sea level to 1500 metres above MSL. A warm moist weather with temperature ranging from 21-°C is ideally suited for the plant.

Vanilla is adapted to a wide range of soil types rich in humus and having good drainage. Vanilla can also be grown in arecanut or coconut gardens having good drainage.

Planting and aftercare

Vanilla is generally propagated by stem cuttings. Vines 60-120 cm long are selected as planting material. The vanilla stem cuttings after collection should be dipped in 1% Bordeaux mixture or copper oxychloride for killing pathogenetic fungi, if any. Usually about one metre long vines are preferred for planting. The vines are coiled around and the base portion is buried in the soil. Cuttings are usually planted directly in the field but they can be raised initially in nursery, if required.

Cuttings are planted at a distant of about 3 m, in rows of 2.5-3 m apart at the foot of the standards. Spacings of 1.2-1.5 m within rows and 2.5-3 m between rows are also recommended. Cuttings are planted in shallow pits. The pits are best filled with humus and mulch and should be raised above the soil surface to avoid water stagnation. The height of the vines should be restricted to facilitate hand pollination and harvesting. Selective pruning of the old vines after flowering is reported to be beneficial even if it

carries few flower buds. Tissue culture technology is also now prefected for the production and multiplication of vanilla.

Manuring

The quantity of fertiliser to be applied may vary according to fertility status of the soil. However, 40-60 g of nitrogen, 20-30 g of Phosphorus and 60-100 g of Potash should be given annually to each vine. Organic manures other than animal manures can also be applied. A 1% solution of an NPK mixture can be sprayed on the plant once in a month. This boosts up growth and flower production.

Flowering and Fertilisation

Vanilla usually starts flowering in the third year of planting, the time depends on the size of the original cutting. The maximum production of flowers is in the 7-8th ear. In Mexico, replanting is done after 9-10th year. The usual flowering season is from December-March and sometimes in October-November. The flowering period may extend for two months but each flower lasts for a day only from early morning to late evening. Flowers are required to be artificially pollinated (hand pollination). Only 6-8 flowers on the lower side of the raceme should be retained and pollinated. Pollination must be done early in the morning. In hand pollination method, a pin or needle or small piece of pointed wood (a wooden tooth pick is ideal) is employed to apply pollen on the stigma of the flower. The pollen of the vanilla flower is produced in a mass *called pollinia, and is covered by hood or anther cap. The stigma is* protected with a lip known as 'rostellum' or 'labellum'. For pollination the stamen cap is removed by a needle exposing the pollinia. Then the flap like rostellum is pushed up and the pollinia are brought into contact with the stigma.

Harvesting and yield

After about 6-9 months of flowering the beans are ready for harvest. The maturity of the beans can be judged by the colour changing from green to pale yellow. At this time, the pods may be 12-25 cm long with 2.5 cm circumference. The right picking stage is

when the free end of the pod starts turning yellow and fine yellow streaks appear on the pods. Daily picking of the mature pod is essential. About 6 kg of green pods produce 1 kg of cured beans. Curing should begin immediately after harvesting, but can be stored for 3-5 days.

A good vanillery is said to yield about 300-600 kg of cured beans per hectare per year during a crop life of 10 years.

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MORPHOLOGY, GENETIC IMPROVEMENT AND CULTURAL ASPECTS OF TREE SPICES AND PROCESSING OF THE PRODUCTS

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Nutmeg, clove, cinnamon and allspice are the tree spices grown in certain pockets of Kerala, Karnataka and Tamil Nadu. There is lot of scope for extensive cultivation of these crops, particularly in the Western Ghats of South India and Assam and North Eastern regions of India.

I. Nutmeg (*Myristica fragrans*, Houtt.)

Morphology:

It is a medium sized tree, usually dioecious. The tree has profuse branching habit. The sex cannot be identified till it flowers. Male flowers are comparatively smaller, with 8-12 stamens having adnate anthers, and in groups. Female flowers are usually solitary with 1 celled superior ovary. Fruit is a drupe. When ripe, the pericarp splits into two halves, explosing the brown testa, surrounded by aril. The nutmeg tree produces two separate spices - nutmeg (seed) and mace (aril). Nutmeg seed contains 6-16% volatile oil.

Cultural aspects:

Propagation is usually carried out by planting fresh, selected seeds in a sand bed of 90 to 120 cm wide, 15 cm thick and convenient length under shade. Germination starts from the 30th day and lasts up to 90 days after sowing. The nursery has to be watered daily with rose-can. The seedlings must be transferred to polythene bags of 15 x 22 cm filled with potting

mixture (forest soil, sand and well decomposed cowdung in 7:7:2 ratio). One year old seedlings are transferred to bigger polythene bags. Two year old seedlings are ideal for field planting. Planting in the main field is done at the onset of monsoon in pits of 75 cm cube at 9 m spacing in both ways. The plants must be shaded to protect them from sun scorch in the early stages. The Kerala Agricultural University recommends application of 20 g N (40 g urea), 18 g P_2O_5 (110 g superphosphate) and 50 g K_2O (80 g muriate of potash) in the first year. The dosage is progressively increased to 300 g N (600 g urea), 250 g P_2O_5 (1560 g superphosphate) and 750 g K_2O (1250 g muriate of potash) per year for a grown up tree of 15 years or more. Copious watering in the early stages of the plant, particularly during summer months, is very essential. To avoid the problem of sex, epicotyl grafts could be planted. In One male tree is recommended for every ten female trees. Harvesting starts from sixth year. The peak harvesting is after 20 years. A good tree yields about 1000 fruits annually, but the yield may vary from a few hundreds to about 10,000 fruits.

Processing:

The harvested fruits are split open. Pericarp is removed and mace is manually separated from the nut. Mace is then flattened out to dry slowly under sun for 10 days to 2 weeks. During drying, mace becomes brittle, turning from scarlet to orange to yellowish-brown, acquiring the pungent aroma. The unshelled nutmeg seeds are dried separately for 4 to 8 weeks under the sun till kernel rattles in the shell. The shell is then broken with a wooden mallet and nutmegs are removed. Nutmeg contains 25-40% fatty oils, known as nutmeg butter. It is obtained by subjecting nuts to hydraulic pressure under heat.

Genetic improvement:

Variability exists for yield and morphological characters in nutmeg. The easy way to achieve the best results is the

selection of high yielding regular bearers with uniform and round nuts from the existing plantations. Controlled crosses between the selected types could also be considered. As the epicotyl grafting is highly successful, grafts can be planted to obtain pure females.

II. Clove (Eugenia caryophyllus) (Spreng. Bull. and Harr.):

Morphology:

The clove of commerce is the dried unopened flower buds of the clove tree. It is a small tree, which lives for about 100 years. The stem forks near the base into 2 or 3 main erect branches. The new leaves appear in flushes and are bright pink. The inflorescence is a terminal, corymbose, trichotomous panicle, branched from the base. Flower is hermaphrodite, speals 4, petals 4 and stames numerous. Ovary is 2 celled and inferior. Fruits (mother of cloves) are drupes and reddish purple.

Cultural aspects:

Method of raising the nursery is the same as for nutmeg. Germination starts 10 to 15 days after sowing and lasts for 40 days. Two year old seedlings are to be planted in the main field in pits of 75 cm cube dug at 7 m spacing in both ways during June-July. Permanent shade trees have to be established in clove gardens. Clove prefers partial shade. The young plant has to be shaded to protect it from scorching. Base of the plant has to be kept clean always and provided with sufficient mulch of dry leaves. Copious irrigation during summer is very essentialy particularly in the early stages. The fertilizer recommendation is the same as for nutmeg. Clove trees start full bearing from 15 to 20 years.

Harvesting and processing:

Harvesting has to be done using step ladders, without breaking branches, when the buds are fully developed and when the base of calyx has turned to pink. The harvested buds are separated from the clusters by hand and spread and dried under sun. buds are raked periodically to ensure development of uniform colour and prevent mold formation. The correct stage of drying is reached when the stem of the bud is dark brown and the rest of the bud light brown. Well dried cloves will be only about one-third weight of the original.

Clove buds are steam distilled to produce clove oil. The main component of clove oil is eugenol.

Genetic improvement:

As self-pollination is predominant and the original introduction in our country is limited, limited variability is only available for cloves in India. It is essential to introduce variability from Indonesia, Zanzibar and Malagasy Republic. Though self-pollination and self-compatibility are reported to be the common feature in clove, occurrence of self-incompatibility has been suspected in some type in other countries and if this could be increased, it will help in evolving hybrid varieties. At present, the long juvenile phase and irregular bearing habit are the main drawbacks which limit investments in clove plantations. Therefore, suitable vegetative propagation methods have to be attempted to overcome these problems.

III. Cinnamon (Cinnamomum verum):

The cinnamon of commerce is the dried inner bark of C. verm. It is indigenous to Sri Lanka. It is the earliest known spice in India. The Chinese cassia or 'false cinnamon' is obtained from the barks of C. aromaticum. It is not cultivated

in India. Tejpat (C. tamala), also known as Indian cassia is cultivated in North East India.

Morphology:

Cinnamon is a bushy evergreen tree, but coppiced generally. Young leaves of the flush are reddish, later turning green. Inflorescence - axillary and terminal panicle. The individual flowers are very samll and pale yellow. Perianth 6 in two whorls, 9 stamens in 3 whorls of 3 each, the innermost one staminodes -3, ovary - superior, fruit - drupe.

Cultural aspects:

Raising nursery is the samo as for clove and nutmeg. Germination starts in 15 days, One year old seedlings are to be planted in pits of 50 cm cube dug at 3m x 3m spacing in June-July. Partial shade in the initial years is advantageous for rapid growth. The young trees are cut back 2-3 years after planting to induce formation of lateral shoots. First harvesting is carried out two years affter coppicing, and subsequent cuttings are taken in alternate years. Cultural operations are restricted to weeding twice in an year an digging soil around during August - September in bigger plantations.

Harvesting and processing:

Stems are cut during September-October to facilitate peeling at the time when red flush of young leaves turn green. The best quality cinnamon is obtained from the bark from shoots in the centre of the bush and from the middle portion of the shoots. Shoots of 1.0-1.25 m length and 1.25 cm thickness are cut from the plant. The rough outer bark is scrapped off with a knife. With a brass rod, the scrapped portion is polished to facilitate easy peeling. A longitudinal slit is made from one end to the other. Then working the knife between the bark and

the wood, the bark is stripped off quickly. The peels are gathered and kept in shade for a day and then in sunlight for 4 days, During drying, bark contracts and assumes shape of quill. The smaller quills are inserted into larger ones to form compound quills. Yield from first crop after 3 to 4 years varies around 60 kg per hectare which subsequently increases. Yields decline usually after 10 years.

Cultivation of cinnamon is in isolated patches and the Randattara Estate at Anjarakkandy near Cannanore with an area of 85 ha is the only large scale plantation in the country.

Genetic improvement:

The survey by NRCS revealed that organized planting of cinnamon is not practiced in India. Generaly a few trees are grown in the backyard as a curio Variation observed in C. verum is very limited. Original source of seed materials for Anjarakkandy is from Ceylon, 180 years back and from here it spread to other areas. Selection of high yielding and high quality lines and multiplication by vegetative means would be advantageous.

IV. Allspice (Pimenta dioica L.) Merr.

The allspice of commerce is the dried immature berries. Jamaica is the main producer of allspice. Its flavour resembles a mixture of cinnamon, clove and nutmeg. It is indigenous to West Indies. There are only a few trees available in Nagercoil, Kallar and Burliar in India. The NRCS experimental farm at Peruvannamuzhi has got 117 trees.

Morphology;

It is a small evergreen tree. Inflorescence - Cyme, Flowers are white and branch trichotomously in the axils of upper leaves. Flowers are structurally hermaphrodite, but functionally

dioecious. Stamens numerous, above 100 in barren trees and 50 in bearing ones. Flowers during March - June. Fruit is a berry, maturing 3-4 months after flowering. It is 2 seeded. Strictly cross pollinated, male trees flower earlier.

Cultural aspects:

The seeds germinate in 15 days and lasts upto 40-50 days. The seedlings can be transferred to bags 3 weeks after emergence above ground level. Six months old seedlings are to be planted at a spacing of 6 m either way. The fertilizer dose is the same as for cloves. Plants start flowering from the seventh to the tenth year, but the peak harvest is obtained from 15 to 20 years.

Harvesting and processing:

Berries are harvested when fully grown, but still green. They are sun-dried and are frequently turned down with laddles. The process of curing lasts 3-12 days, till berries are dried completely. Curing is complete when berries become crisp and produce a metallic sound, if shaken. A tree yields 50 to 60 kg of dry berries.

Pimento berry oil:

Small quantities are produced in Jamaica. Oil is distilled commercially. Total yield of oil from pimento berries varies from 3.3 to 4.5 per cent.

Pimento leaf oil:

Leaf oil is distilled only in Jamaica from leaves removed during harvesting of berries. Oil yields from dired leaves range from 0.7 to 2.9 per cent while fresh leaves provide 0.35 to 1.25 per cent.

Crop improvement:

Selection of improved clonal material of known sex from heterogenous population should give promising results. In addition to yield, attention should be paid to shape, with low branching to facilitate harvesting and resistance to disease.

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CULTIVATION OF CARDAMOM INCLUDING NURSERY PRACTICES

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Cardamom (Elettaria cardamomum Maton) is popularly known as "Queen" of Spices. The total estimated area under Cardamom in India is 94,000 ha. distributed in Western Ghats of Kerala (60%), Karnataka (30%) and Tamil Nadu (10%). Cardamom exports fetched Rs.6.80 crores during the year ended March, 1993 and the production is expected to cross 6,500 tonnes this year. In recent years, Gautemala emerged as a keen competitor in the international market offering almost $ 8 less per kg. compared to Indian Cardamom. There is an urgent need to increase yield of Indian Cardamom by adopting appropriate agrotechniques to retain the ever premier position India had in the Cardamom map of world.

Cardamom is largely used as masticatory flavouring agent in cooking, confectionery and for medical purposes. In the Scandinavian countries, it is used for flavouring cakes and pastries. In Arab countries, a beverage made from coffee and cardamom is offered to guests as a gesture of good-will and hospitality. This cardamom coffee is called Ghawa.

Cardamom grows well in warm and humid climate with temperature ranging 10-35°C and fairly well distributed annual rainfall over 150 cm.at altitude 600 to 1200 metres. The soil test results indicated that cardamom growing soils are rich in organic matter and nitrogen and low to medium in available phosphorus and potassium. PH of Cardamom growing soils ranges from 4.5 to 6.5. There are three types in Cardamom viz. Mysore (prostrate), Malabar (erect) and Vazhukka (semierect). Malabar type is cultivated in Karnataka and the Mysore type in Kerala and parts of Tamil Nadu.

Propagation

Cardamom is propagated by seedlings and suckers. Propagation by seedlings is largely practised. The suckers are used mainly for gap filling in plantations. Propagation of cardamom by using suckers is cheap and they commerce bearing about a year earlier than transplanted seedlings. It is advantageous in area where 'Katte' disease is not a problem. The method of propagation by rhizome consists of splitting up established clumps into sections consisting of at least one old and one young shoot. The section of rhizome is placed in shallow depression made in the pit which is then filled with soil and covered with mulch.

Raising nursery: There are two stages in the nursery viz. the primary nursery and the secondary nursery. Seeds are collected from fully mature, well formed fruits from compact panicles of profusely bearing and vigorous plants, preferably of more than 5 year old clump, free from pests and diseases. Seed capsules are collected during 2nd and 3rd round picking. After picking, capsules are immersed in water and pressed gently for extracting seeds, which should then be washed in cold water for removing mucilaginous coating on seeds. After draining water, seeds should be mixed with wood ash to avoid stickiness and this facilitates sowing. Seeds should be dried in shade for 2 to 3 days. To ensure uniform and early germination, seeds should be sown soon after extraction.

Nursery beds: It is always better to select nursery site on moderately slopy land, near a perennial source of water. The nursery area should be cleared off all existing vegetation, stumps, roots, stones, etc. Raised beds are prepared after tilling land to a depth of about 30 to 45 cm. Usually the beds of one metre width and convenient length (5to 6 m) and raised to a height of about 30 cm are formed. A thin layer of humus rich forest soil is spread over beds. Soak the soil in the seed bed to a depth of 15 cm. with 1:50 formaldehyde solution to control damping off disease of seedlings.

Time of Sowing: August and September are the ideal months for sowing cardamom seeds to get maximum germination and stand of the seedlings. Germination will be poor if the sowing is delayed as temperature will be low during winter.

Sowing: Seeds are either broadcasted or sown in lines, usually not more than 1 cm.deep. Rows are spaced 15 cm. apart and seeds sown 1 cm. apart within a row. The seed rate is 5 g per square metre in Karnataka and 10 g in Kerala and Tamil Nadu. After sowing, the seeds are covered with a thin layer of fine sand or soil and pressed gently with a wooden plant. Beds are mulched to a thickness of abour 2 cm. with paddy straw or other suitable materials. Thereafter, beds are watered daily. Germination commences in about 30 days and continues for a month or two. Mulch may be removed soon after commencement of germination. Shade is provided to beds by erecting a pandal two metres in height using cut branches of trees like Jacktree which do not shed leaves, coconut fronts or coirmat.

Secondary nursery: The seedlings are transplanted to the secondary nursery when they attain four to five leaf stage. The beds for secondary nursery are prepared in the same manner as for primary nursey. A layer of well rotten cattle manure or jungle soil is spread over secondary nursery beds and mixed with top 5 cm. of soil. Transplanting is done in December or January in Karnataka and May/June in Kerala. Seedlings are spaced at least 15 cm. apart and beds watered regularly.

Shading the beds: To protect seedlings from sun, shade has to be provided by erecting a pandal sloping from east to west. Sloping pandal will also protect seedlings from mechanical damage caused by rain; For providing shade, locally available shade tree twigs which do not shed their leaves, coconut fronts, coir mat etc. may be used.

Age of seedling for transplanting in the estate (Main field)

In Karnataka 10 months old seedlings are used for planting in the estate whereas in Kerala, it is most common to plant 18-22 months old seedlings.

Planting in the main field (estate)

The initial work consists of clearing all undergrowth and thinning out excess shade trees or branches to have an evenly thick overhead canopy. If the land is slopy, it is advisable to start clearing from top and work downwards. Pits of 45 x 30 cms. may e dug in April-May and filled with a mixture of surface soil and compost or well rotten farmyard manure. The spacing commonly adopted for Malabar type is 2m x 2 m in Karnataka and 2 m x 3 m, for Mysore and Vazhukka types in Kerala - Tamil Nadu regions.

The best season for planting is rainy season commencing from June. Planting may be avoided during heavy showers. Cloudy days with light drizzles would be ideal for planting. The usual practice is to make a small depression in the filled soil and plant the seedlings in the centre for the depression. Deep planting should be avoided as it results in suppression of growth of new shoots and may cause death of plants due to decaying of underground rhizomes. Immediately after planting, the seedlings should be supported by stakes.

After care:

A regular schedule of cultural practices consisting of mulching, weeding, trasning, shade regulation measures and fertilizer application are to be followed for maintaining a good cardamom plantation.

Mulching: Make use of naturally bestowed leaf of the shade trees for mulching. It helps cardamom plants to conserve soil moisture quite necessary particularly during summer.

Weeding: In the first year of planting, frequent weeding is quite essential to eliminate root competition between young cardamom seedlings and weeds. Subsequently, depending upon intensity of weeds, 2 to 3 rounds of weeding in a year would be necessary. The first round of weeding is to be carried out in May-June, the second in August-September and third in December-January. Weeds removed during first and second rounds may be heaped in the inter row space and allowed to decay. After decaying they may be used for mulching. In December-January, weeds removed may be directly used for mulching.

Trashing: Trashing consists of removing old and dry shoots of plant. It should be carried out once in a year between February-March.

Shade regulation: Light shade is more favourable for cardamom in the initial stages of growth to enhance tillering. Where the land selected for planting has only sparce tree growth suitable quick growing shade trees need to be planted. Temporary shade trees such as Erythrina sp. and permanent shade trees such as Red cedar (Cedrella toona Roxb) Balangi (Acrocarpus fraxinifolius Wt.) or Jack (Artocarpus hetorophollus Lamk) would be suitable. Presence of shade trees like red cedar which shed leaves in monsoon, in the midst of ever green forest trees afford natural shade regulation. The temporary shade trees can be removed by the time, permanent shade trees develop canopy sufficient to provide shade for Cardamom plants. Trees having well distributed branching habit and small leaves are ideal for Cardamom.

To provide adequate light during rainy season, when the intensity of light is less, it is necessary to carry out shade regulation before the onset of monsoon. May is the proper time for thinning out shade trees. It is equally necessary that there should be sufficient shade by the time summer starts, for providing protection from the hot sun.

Light earthing up: The rich humus top soil around the plant to a distance of 75 cm. may be scraped and applied as a thin layer to

the base of the clup just up to the collar region. It forms the soil mulch and covers the exposed roots and rhizomes due to beating action of rain drops.

Fertilizer: A fertilizer dose of 75 kg. N, 75 kg. P_2O_5 and 150 kg. K_2O per hectare is recommended. However, appropriate corrections have to be made based on soil test values. Fertilizer is applied in two aplit doses. The first application during May helps production of suckers and development of capsules and the second application during late September helps intiation of panicles and suckers. Cardamom is a surface feeder, hence deep placement of fertilizer is not advisable. Apply the fertilizer at a radius of 30 cm. where most of the roots are present. After applying fertilizer, it should be mixed and incorporated in the soil.

Irrigation: Normally irrigation commences at the cessation of monsoon rains by December. Cardamom is often cultivated in an undulated topography of land, so sprinkler irrigation is the most suitable and a convenient method. Depending upon the layout of land and the soil type, irrigation at an interval of 10-15 days is given in the estate till commencement of monsoon.

Drainage: Cardamom plants are sensitive to high water table and consequent water logged condition. If the area is water logged, drains are to be provided at suitable intervals. Main drains at interval of 10 m and lateral drains at 4 to 6 m interval may be provided.

Harvesting: Cardamom plant starts bearing fruits from the 2nd year after planting. However, satisfactory yeidls are obtained from 3rd year onwards. In most of the areas, peak harvest is in October-November. Picking is carried out at intervals of 15 days and completed in 7-8 rounds.

Processing: After harvest, Cardamom capsules are dried either in the sun or in specially build drying house by radiation of heat. The capsules kept for drying are spread thinly and stirred frequently to ensure uniform drying. The latter process also

helps to retain green colour of the capsules which fetches better price in the market. The dried capsules are rubbed with hand or with rough coir mat or wire mesh and winnowed to remove other plant residues and foreign matter. They are then sorted according to size and colour.

Bleached cardamom is yet another distinct trade quality. Bleaching is accomplished by exposing dried capsules to action of sulphur dioxide. In Haveri (Dharwar District), a particular well water containing sulphur is also made use of for bleaching Cardamom.

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NURSERY PRACTICES AND CULTIVATION OF BLACK PEPPER

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Black pepper (Piper nigrum L.), known as king of spices, is the most important foreign exchange earner among spices grown in India. The estimated world production of pepper during 1992-93 is 2.08 lakh tonnes. India has the largest area under pepper in the world but the productivity is the lowest (250 kg/ha) as against the global average of 490 kg/ha. The major pepper producing countries in the world are India, Brazil, Indonesia and Malaysia. The productivity in Thailand, Malaysia and Brazil are 4200, 2925 and 1580 kg per ha, respectively. The differences in the average productivity are attributable to differences in cultural practices adopted, defective utilisation of various resources and low use efficiency of inputs. In India, Kerala accounts for 94% of area and production of pepper followed by Karnataka and Tamil Nadu. In contrast to such a low average yield, several farmers in Kerala have harvested over 1 kg.

Pepper is also grown in a few areas of Andhra Pradesh, Orissa and North-eastern Region. It performs well in Andaman and Nicobar Islands where there is ample scope for extending its cultivation. It has now spread to Goa and Maharashtra.

1. Crop requirements :

Climate : Pepper is a plant of humid tropics requiring adequate rainfall and humidity. The crop tolerates temperatures between 10° and 40°C. It grows successfully between 20° north and south latitude and from sea level upto 1500 m MSL.

Soil : Pepper can be grown in a wide range of soils with a pH of 4.5 to 6.0. It grows well in well drained loamy soils rich

in organic matter though in its natural habitat, it thrives well on red laterite soils. If there is a choice, slopes with a southern direction are to be avoided. Pepper grows successfully on such slopes if sufficient protection from the scorching summer sun could be provided to the plants by growing shade trees. The pepper growing areas on the West-coast of India can be conveniently classified as :

1. Coastal areas where pepper is grown in almost every homestead or plot of land.
2. Slopes and valleys where pepper is extensively cultivated on a plantation scale.
3. Hills at an elevation of 200-1500 m where the crop is trailed on shade trees in coffee plantations.
4. Valleys as a mixed crop in arecanut gardens in Northern part of Cannanore, Kasaragod, Dakshina Kannada and Uttara Kannada districts.

Varieties :

More than 75 cultivars of pepper are being cultivated in India. Karimunda is the most popular of all the established cultivars of pepper grown in all districts of Kerala. The other important cultivars are Kottanadan (South Kerala), Narayakkodi (Central Kerala), Aimpiriyan (Wynad areas), Neelamundi (Idukki areas), Kuthiravally (Calicut and also in Kumali region), Balancotta and Kalluvally (in Northern Kerala) and Malligesara and Uddagare (in Karnataka). Panniyur 1 and 3 hybrid peppers evolved at the Pepper Research Station, Panniyur have Uthirankotta and Cheriakaniakadan as its female and male parents respectively. The average yield potential being 2.2 kg of black pepper. Under extensive shade and higher dose of nitrogen, the hybrids show a tendency for increased vegetative growth and corresponding decrease in yield.

In terms of quality, Kottanadan has the highest oleoresin (17.8%) followed by Aimpiriyan (15.7%). Based on the research work done at NRCS, Calicut, two Karimunda selections viz., KS 14

and KS 27 were identified for release at the Tenth Workshop of All India Coordinated Research Project on Spices. These selections recorded yields upto 4 kg (green) per vine at Peruvannamuzhi on red lateritic soil. During 1991 high yielding variety Aimpiriyan and nematode tolerant 'Ottaplackal-1' are identified.

Standards :

Live standards : Pepper vines are trained usually on live standards like Erythrina indica where it is grown as a pure crop. The other standards used are :

1. Garuga pinnata
2. Grevilea robusta
3. Glyricidia sepium
4. Leucaena leococephala

When E. indica and G. pinnata are used, the stem cuttings are made in March-April and stacked in shade in groupes. These start sprouting in May and planted in the edge of the pits dug for pepper vines when the first showers are received in May-June. Glyricidia stem cuttings can be planted directly on the edge of the pit taking care not to peel off the bark at the cut end. Whenever E. indica is used as standard, application of carbofuran 3 G @ 30 g may be done once in a year to control pests.

As a mixed crop, it is trained in jack, mango, coconut, arecanut etc. There is lot of scope for extending cultivation in this manner, particularly as a component crop in multi-storeyed/high density multispecies cropping systems. Growing of pepper as intercrop in Coffee and Tea plantations utilising the existing shade trees like Silver oak and Jack is popular.

Non-living standards : Experimental results show that growing pepper in RCC and granite poles results in more than 100% increase in yield when compared to growing pepper in living standardes. Providing shade through planting of shade trees at

regular intervals is essential for getting optimum growth of pepper vines while using non-living standards.

II. Production of quality planting materials :

The conventional method of production of planting materials in pepper involves use of 2-3 noded cuttings of runner shoots raised in polybags in nursery. The disadvantages are :

1. Need to have large quantities of planting materials
2. Low sprouting
3. Poor root development, and
4. Poor field establishment

In the new method for rapid multiplication, pepper vines are grown over the rooting medium filled in bamboo split pieces. As the vines grow, the nodes get rooted, and each of these nodes is later separated and planted in individual polybags.

III. Establishment of a plantation :

Site selection : When grown on a slopy land, the slope facing south should be provided with sufficient shade trees to protect from the scorching summer sun. It is preferable to plant on the lower half of north and north-eastern slopes.

If the land is levelled and plain, provision of good drainage is very much essential.

Preparation of land :

Where virgin land is available, they are cleared of all undergrowth, forest trees and stumps of dead trees. Selective thinning of trees may be done in such a way that the young pepper vines planted get sufficient shade for its optimum growth.

Pits of size 50 cm^3 are dug at a spacing of 2.5 m x 2.5 m (1600 plants/ha). The pits are filled with green leaves and top

soil. Five kg FYM or well rotten compost per pit is applied and mixed with the soil (April-May).

Planting standards :

Stem cuttings of E. indica, L. lithosperma. C. soplum and G. pinnata or the seedlings of Silver oak are planted with the receipt of first rains.

In RCC poles, the following specifications are adopted :

Length - 3.6 m

Thickness - 10 cm

While fixing the RCC poles 0.6 m length of pole should go inside the soil.

Planting pepper :

Two or three rooted cuttings of pepper are planted individually in pits on northern side of each standard.

Cultural practices :

Vine tying : As cuttings grow, the shoots are tied to the standards as often as required. The young vines should be protected from hot sun during summer months.

Shade regulation : Regulation of shade by lopping the branches of standards is necessary not only for providing optimum light to the vines but also for enabling standards to grow straight. Normally two loppings are done - one during May and the other during October-November.

Mulching : Mulching around the pepper vines with green leaves (10 kg), saw dust, hay or rice husk to a radius of 1 metre is required not only to control weeds in the pepper basins but also to conserve soil moisture. It results in improved plant

growth irrespective of nematode population, and with mulching soil temperature at 5 cm depth seldom rises beyond 30°C.

Cover crops : Cover crops such as Calapagonium mucunoids and Mimosa invisa are recommended to provide soil cover and prevent soil erosion. Hay also serves as mulch during summer. A combination of nematicide (if slow decline is diagnosed) mulch and a non-competitive soil cover is good for optimum growth of vines. Congo signal grass is also a good cover crop.

Manuring :

Dose of NPK/Vine/Year : 140:55:270 g. If the soil test show low level of K, it can be increased upto 280 g/vine.

The following schedule is adopted :

On the year of planting	:	1/3 of the above dose in September.
Second year of planting	:	2/3 of the recommended dose in two splits, one during May-June, other during September-October.
Third year of planting	:	Full dose applied in two splits, one during May-June and the second during September-October.

Fertilizers are applied at a distance of about 30 cm all around the vine and slightly raked up.

FYM @ 10 kg.vine/year is recommended. It is to be applied during May. Lime @ 500 g/vine is also applied in alternate years.

Irrigation :

The black pepper is seldom irrigated. However, the trials conducted at Panniyur Research Station showed that irrigation based on 0.25 IW/CPE upto March resulted in increased yields. There is scope to introduce drip irrigation for higher productivity of black pepper.

Harvesting and yield :

Flowering in pepper starts during May-June. The crop takes about 6-8 months from flowering to harvest. Harvesting starts from December and continues in stages. Harvesting is done with the help of ladder made of aluminium or bamboo. During harvesting the whole spike is hand picked when one or two berries in the spike turn bright orange or purple. The berries are separated from the spikes and dried in the sun for 7-10 days.

The white pepper of commerce is prepared from either freshly harvested berries or dried black pepper using special techniques such as water steeping, steaming or decortication. The quantity of black pepper from green pepper is about 33% and that of white pepper from green pepper is about 25%.

Yield :

The average yield of black pepper (dry) obtained from a vine under ideal management conditions is 2 kg/year.

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RECENT ADVANCES IN CULTIVATION, MANAGEMENT AND PROCESSING OF GINGER & TURMERIC

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I. GINGER

India is the world's largest producer of dry ginger next to China and contributes about 38% of the world production. Other countries cultivating ginger extensively are West Indies, Brazil, Japan and Indonesia. To meet the world's demand of 7.3 lakh tons of dry ginger by 2000 AD, India has to step up her production at the rate of 8% annually. In India, Kerala, Orissa, Andhra Pradesh, Himachal Pradesh, Meghalaya and West Bengal are the important states growing ginger. About 60% of the area is confined to Kerala which accounts for 25% of the country's production.

Climate :

Ginger grows well in warm and humid climate. The crop is cultivated up to an altitude of about 1500m MSL. The optimum elevation for its successful cultivation is 300-900 meters. Moderate rainfall at sowing time till rhizomes sprout, fairly heavy and well distributed showers during the growing period and a dry weather of about one month before harvesting is the optimum requirement for a successful crop. Studies showed that early planting helps in better growth, and development of rhizome less incidence of disease and higher yields.

Soil :

A soil rich in iron and organic matter with good drainage and aeration is ideal. It comes up well in wide range of soils, with good drainage and aeration like sandy or clayey loam, red loam or lateritic loam soils. Drainage is absolutely necessary for less disease incidence. Ginger should not be grown in the same site year after year, as the crop is prone to pests and diseases.

Varieties :

Several cultivars are grown in different areas in India. They are Maran (Assam), Kurappampadi, Ernad and Wynad (all from Kerala). Some of the varieties with specific qualities are given below:

High dry ginger	-	Maran, Nadia, Karakkal
High oleoresin	-	Ernad Chernad, China, Rio-de-Janeiro
High volatile oil	-	Sleeva Local, Narasapattam, Himachal
For green ginger	-	Rio-de-Janeiro, China, Wynad Local, Maran

Seed rate :

About 1200-1800 kg/ha and rhizome bits of minimum 15 g may be used for planting in individual pits.

Seed treatment :

Ginger is always propagated by portions of rhizomes known as seed rhizome. Rhizome bits are treated with 0.3 per cent Dithane M-45 solution for 30 minutes against fungal diseases. It may also be treated with insecticide (0.05%) malathion and bacteriocide solutions (200 ppm streptocycline) against scale insect and bacterial wilt.

Planting :

Land preparation : The land is to be ploughed 4 to 5 times to bring the soil to a fine tilth. In heavy rainfall area beds of about 1m width 15cm height and of 3m length or of any convenient length are prepared at an inter-space of 40cm between beds. One hectare land accommodates 2000 beds of 3m x 1m after leaving intermediate space between beds. In irrigated crops, ridges are formed 40 cm apart and planted.

Spacing :

The optimum spacing is 25 to 20 x 15 cm under bed system of planting. A bed of 3 x 1m accommodates 40 plants, 10 plants in length wise and 4 plants in width wise.

Manuring :

A basal dressing of 25-30 tonnes of FYM with NPK fertilizers 75:50:50 kg/ha are recommended. Whole of P_2O_5 and half of K_2O may be applied at the time of planting. Half of nitrogen is applied 40 days after planting and the balance N and K_2O three months thereafter. Application of neem cake at 2 tonnes per ha as a basal dressing helps in reducing incidence of soft rot of ginger to an extent and increase in yield.

Weeding and mulching :

Mulching enhances germination, increases soil organic matter and conserves soil moisture and prevents washing of soil due to heavy rains. The first mulching is done at the time of planting with 12.5 tonnes of green leaves per ha and a second mulching done after 45 days with 5 tonnes of green leaves per ha.

Rotation and inter-cropping of ginger :

The crops most commonly rotated with ginger in Kerala are tapioca, chillies, dry paddy, gingelly etc. Ragi, groundnut, maize are other crops rotated with ginger.

Ginger is also grown as an inter-crop in coconut and arecanut gardens. The employment generated in inter-cropping is estimated as 108 man days and 24 woman days. This is in addition to the requirement of man and woman days required for the main crop of coconut and arecanut. The additional income is Rs.5,000/ha.

Harvesting :

The crop is ready for harvest in 8 months time, when the leaves turn to yellow and start drying up. The average yield (fresh) ranges from 15-30 t/ha. If the crop is for green ginger, it is harvested in 6-7 months. Rhizomes are washed thoroughly in water two or three times to remove the soil and dirt and dried in shade for a day and marketed.

For dry ginger, the outer skin is removed with split bamboos having pointed ends. Only the outer skin is to be peeled, since the essential oil of ginger remains near the skin, and dried in the sun for a week. Yield of dry ginger is 16-25% of the green ginger depending on the variety.

Preservation of seed ginger :

Big plumpy rhizomes free from diseases are selected immediately after harvest, treated with a solution containing 0.05 per cent of Malathion and Dithane M-45 (0.3 per cent) for 30 minutes. Drain the solution and dry the rhizomes under shade. Dried rhizomes are put in a pit of convenient size (2x1x1m) and covered with a plank fitted with 2-3 holes for aeration. In some areas the rhizomes are loosely heaped over a layer of sand or paddy husk and covered with dry leaves in a thatched shed.

Soil amendment studies :

Application of organic amendments like neem cake at two tons per hectare resulted in significant increase in the availability of nutrients in the soil, increased yield of ginger by 33% and restricted incidence of rhizome rot of ginger to 4.7% only.

Burning the surface soil using dry leaves increased the soil pH, P and K status in soil. This along with advancing the date of planting to the pre-south-west monsoon period combined with use of Dithane M-45 (0.2%), Metacid (0.05%) resulted in significant germination (95%), lower incidence of rhizome rot (11%) and increased yields (34%).

Uses :

Ginger is used in many ways in culinary purpose both as green and dry form. It is used as a spice for preparation of ginger wine, ginger beer, and as a carminative and aromatic stimulent to the gastro intestinal tract.

Constraints in production and remedial measures :

Major constraints in production are diseases due to rhizome rot and bacterial wilt. None of the existing cultivars are tolerant to these diseases and breeding for resistance is difficult for want of seed set in ginger. The other alternative seems to be selection of mutants from plantlets raised by cell or callus culture.

II. TURMERIC

Turmeric is the dried rhizome of Curcuma domestica (Syn. C. longa). It is a tropical herb of either Indian or Chinese origin. Turmeric is widely cultivated in tropics, more especially in India, Ceylon and many of East Indian Islands, Fiji, Queensland, China, Formosa and Indo-China. In order to meet the world demand of 37,500

tonnes of dry turmeric by 2000 A.D. India's target of export is fixed at 30,000 tonnes. In order to achieve this, an annual growth rate of 10% is envisaged. India is the largest producer of turmeric in the world. Andhra Pradesh, Tamil Nadu, Bihar, Orissa, Maharashtra and Kerala are the major turmeric producing states of the country. It combines in itself the properties of a spice and a dye. As per the official figure 1992-93 India exported 19 thousand MT of turmeric earning Rs.46 crores. Andhra Pradesh and Tamil Nadu jointly contribute about 70% of the production in India. Kerala's production is only 6200 MT, however, the bulk of it is exported because of superior quality.

Climate :

Turmeric is a tropical crop cultivated from almost sea level to 1500 m MSL in places of moderate rainfall of 1500 mm and a temperature ranging from 20-30°C.

Soil :

It thrives best in well drained sandy or clayey loam soils. Red loamy soils are ideal for turmeric. Turmeric requires good drainage.

Planting material :

Whole or split mother rhizomes as well as finger rhizomes are used. A seed rate of 2500 kg/ha is optimum. The seeds are treated with 0.3% solution of Dithane M-45 for 30 minutes against diseases.

Varieties :

Duggirala, Tekkurpet, Sugandham, Amalapuram (all from Andhra Pradesh) and Alleppey (Kerala) are some of the important varieties cultivated. Among the clonal selections Suvarna, Suguna and

Sudarshana yielding 25-35 tonnes (fresh) with a curcumin content 4 to 6 per cent were released for cultivation by NRCS. The other popular varieties are Roma (Orissa), Co-1, BSR-1 (Tamil Nadu).

Preparation of land and planting :

The land is prepared and brought to a fine tilth by repeated ploughings. The raised beds of size 1m width and convenient length with 15 cm height and a spacing of 40 cm between beds are prepared in high rainfall areas like Kerala. Planting is also done in ridges and furrows. The spacings are 30x25cm on beds. In the case of ridges and furrows, the ridges are 45 cm apart and planting is done 25 cm apart along the side of ridges.

Manuring and mulching :

Basal dose of FYM @ 40 tonnes/ha are applied and ploughed. In soils poor in nutrients, fertiliser dose of 60:50:120 kg NPK/ha for high yielding variety. The whole of P_2O_5 and half of K_2O are applied, as basal. The 30 kg N is applied 45 days after planting and the balance 30 kg N and 60 kg K_2O are applied 3 months after planting. The beds are to be earthed up after each fertilizer application.

The crop is mulched immediatley after planting with green leaves at the rate of 12,000-15,000 kg/ha. It is repeated for a second time with the same quantity of green leaves. Three to four weedings are necessary depending upon the weed growth.

Studies on the nutrient requirements of improved cultivars of turmeric (Suvarna, Suguna and Sudarshana) released by NRCS have indicated that nutrients applied is reflected more in the rhizome than in the leaf. Application of of NPK at 60, 50, 120 kg/ha gave maximum yield in Sudarshana (33.2 t/ha) followed by Suguna (29.3 t/ha) and Suvarna (27.1 t/ha). Application of micronutrients like Manganese, Zinc, Molybdenum and Boron increased the yield of turmeric by 10-15%.

Intercropping :

Turmeric comes up well under partial shade conditions, but thick shade affects the yield adversely. It is recommended, as an inter-crop in coconut and arecanut gardens. It can also be mixed with red gram, sunhemp, chillies, colocasia, onion, brinjal and cereals like maize, ragi etc. Under Maharashtra conditions, turmeric and radish gives the highest monetary returns.

In the case of irrigated crop, depending upon the weather and soil conditions about 15-20 irrigations in 7 to 10 days intervals are given in clayey soil and about 40 irrigations in sandy loams.

Harvesting and yield :

Turmeric is harvested 8-9 months after planting. The average yield of fresh rhizomes under good management is 25-30 tonnes per ha.

Production constraints and remedial measures :

Non-availability of quality disease free material in sufficient quantity, poor adoption of improved crop management, by farmers, rhizome rot incidence are the major constraints in production. Making available the improved varieties for cultivation, credit facilities are some of the remedial measures.

Processing :

Curing : Fingers are separated from mother rhizomes and washed free of soil (Mother rhizomes are usually kept as seed material). The fresh turmeric is cured for obtaining dry turmeric. Curing involves boiling of fresh rhizomes in water and the drying in the sun.

The traditional method of curing is as follows: The cleaned rhizomes are boiled in copper or galvanized iron or earthen vessels, with water just enough to soak them. Boiling is stopped when froth comes out and white fumes appear giving out a typical odour. The boiling lasts for 45-60 minutes when the rhizomes are soft. The stage at which boiling is stopped largely influences the colour and aroma of the final product. Overcooking spoils the colour of the final product while under-cooking renders the dried product brittle.

The improved scientific method of curing turmeric is as follows: The cleaned fingers (approx. 50 kg) are taken in a perforated trough of size 0.9 x 0.55 x 0.4 mm made of GI or MS sheet with extended parallel handle. The perforated trough containing the fingers are then immersed in the pan. The alkaline solution prepared by dissolving 100g of sodium bicarbonate or sodium carbonate in 100 litres of water is poured into the trough so as to immerse the turmeric fingers. The whole mass is boiled till the fingers become soft. The cooked fingers are taken out of the pan by lifting the trough and draining the solution into the pan. Alkalinity of the boiling water helps in imparting orange yellow tinge to the core of turmeric. The drained solution in the pan can also be used for boiling another lot of turmeric along with the fresh solution prepared for the purpose. The cooking of turmeric is to be done within two or three days after harvesting.

The rhizomes may also be placed in baskets with perforated bottom and sides, and then dipped in covered tanks when the quantity is large or may be put directly into the vessels when the quantity is small. The mother rhizomes and the fingers are generally cured separately.

Drying :

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on bamboo mat or drying floor. A thinner layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the material should be heaped or covered. It may take 10-15 days for the rhizomes to become completely dry. Artificial drying, using cross-flow air at a maximum temperature of 60°C is also found to provide satisfactory product. In the case of sliced turmeric, artificial drying had clear advantages in giving brighter coloured product than sun drying which tends to suffer surface bleaching. The yield of the dry product varied from 20-35% depending upon the variety and the location where the crop is grown.

Polishing :

Dried turmeric has a poor appearance and a rough outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface or trampling them under feet after wrapped in gunny bags. The improved method is by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against the mesh as well as by mutual rubbing against each other as they roll inside the drum. The turmeric is also polished in power operated drums. The yield of polished turmeric from the raw material varies from 15-25 per cent.

Colouring :

Colour of the turmeric always attracts the buyers. Yellow colouring is given externally to the rhizomes while polishing by a dry or wet process. Turmeric powder is added to the polishing drum in the last 10 min. in dry process. In wet process turmeric powder is suspended in water and mixed by sprinkling inside the polishing basket. For giving a brighter colour, the boiled, dried and half polished fingers are taken in baskets which is shaken continuously after emulsion is poured in. When the fingers are uniformly coated with the emulsion, they may be dried in the sun. The composition of the emulsion required for coating 100 kg of half boiled turmeric is : Alum 0.04 kg, turmeric powder 2 kg and castor seed oil 0.4 kg.

Preservation of seed rhizomes :

Rhizomes for seed purpose are generally stored after heaping under the shade of a tree or in well ventilated shade and covered with turmeric leaves. Some times the heap is plastered with earth mixed with cowdung. The seed rhizomes can also be stored in pits with saw dust. The pits can be covered with wooden planks with one or two holes for aeration.

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DISEASES OF BLACK PEPPER AND THEIR MANAGEMENT

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A sound knowledge of black peper diseases is an essential prerequisite for effective management of the crop to ensure optimum production. Black pepper is susceptible to various fungal, bacterial and nematodal diseases both in the nursery and in grown up plantations.

I. NURSERY DISEASES

Pepper nurseries are raised during February-March and rooted cuttings will be ready for planting during June-July. Nurseries with conventional method of raising rooted cuttings with runner shoots, are faced with problem of disease incidence often. However in the nurseries with the rapid multiplication method standardised at National Research Centre for Spices, Calicut (bamboo method), with single node rooted cuttings, the disease problems are minimal. Conventional nurseries are raised under heavy shade with high frequency of irrigation to ensure high humid condition essential for rooting. These warm humid conditions with temperatures below 30°C, prevailing in the nursery are also congenial for fungal infection caused by Rhizoctonia solani, Sclerotium rolfsii and Phytophthora capsici.

Leaf rot and blight of rooted cuttings
(Causal organism: Rhizoctonia solani)

This soil-borne fungus infects both leaves, stems and roots. Foliar infection occurs when soil particles are splashed on to plants while watering. Infection on leaves starts as dark grey

spots which enlarge irregularly forming dark grey patches. In severe cases, leaf rot sets in. The enlarged necrotic patches appear dark grey and brittle. Mycelium (fungal threads) grows fast from these infected patches. The adjacent infected leaves get appressed to each other due to this fast growing mycelial net work arising from infected patches. Often, infection occurs anywhere on the stem of the cuttings resulting in its death. When infection occurs in the middle of the stem, the foliage beyond that point of infection wilts and dries up. The fungus forms small sclerotia in dried infected tissues, which form further source of infection.

Sclerotium wilt or basal wilt
(Causal organism: Sclerotium rolfsii)

The fungus infects both leaves and stems. On leaves, it forms depressed necrotic spots which enlarge, forming round to irregular spots with a concentric zonation. Occasionally the enlarged brittle infected portion drops off, showing a 'shot hole' effect. On stem, it clearly shows up bright whitish mycelium advancing rapidly. The stem colonised by this fungus shows watery rot and the infected cutting dies out. The whitish mycelium turns cream coloured and whitish grey coloured grain like bodies called sclerotia appear. These bodies get disseminated and each one of them infects a fresh plant.

Control measures

1. All the affected cuttings when noticed should be removed from the main nursery and destroyed.

2. Foliar spraying can be given to all cuttings with either 1% bordeaux mixture or 0.2% copper oxychloride (Fytolan or blue copper 2 g/litre) or 0.2% bavistin at 15-30 days intervals during June-July. While spraying, the lance can be focussed on to the soil surface of the bag so that soil also gets drenched with the fungicide.

3. When sclerotia, the tiny brown fruiting bodies of the fungus are seen on the infected stem, care should be taken not to spill them at the time of removal. This can be done by carefully collecting infected plants in a bucket and burning them off.

Leaf rot/Leaf spot
(Causal orgnaism: Phytophthora capsici)

Apart from the major vine death (foot and root rot) caused by P. capsici, leaf rot and leaf spot infections are also found in severe form, in certain nurseries where runner shoots collected from infected gardens are used for raising rooted cuttings. The rooted cuttings in the nursery being tender are more vulnerable to infection. Regular spraying (monthly) during monsoon period and drenching with 1% bordeaux mixture or 0.2% copper oxychloride would be effective in checking this.

General precautions

1. Runner shoots meant for raising nursery, should not be collected from diseased gardens indiscriminately. Soil particles adhering to these cuttings (especially when colected from runner shoots which struck roots in the soil) form the major sourse of infection. From the selected vines, runner shoots are to be kept coiled and rested on a raised stake, so that it will not come in contact with the soil, which is the main source of soil borne pathogens.

2. Bundles of (two to three node) cuttings ready for planting can be washed thoroughly and kept in 0.2% bavistin for 30 minutes and later planted to reduce chances of infection.

3. It is always desirable to raise the cuttings in fumigated nursery mixture to check the disease problems at the nursery stage itself. This will ensure good growth and disease free

cuttings. Raising single node rooted cuttings in bamboo splits would be desirable to avoid chances of infection.

4. Avoid nursery sites prone to inunduation and stagnation.

5. Change the nursery site at least once in three years.

6. Incorporation of inoculum of VAM (Vescicular arbuscular mycrorrhiza) into the nursery mixture would promote growth and suppress root infection.

II. DISEASES AFFECTING THE GROWN UP VINES

Phytophthora foot rot
(Causal organism: Phytophthora capsici)

The disease occurs during June to September coinciding with South West monsoon. High soil moisture and relative humidity (91-99%) and low temperature (22.5-29.6°C). Shorter duration of sunshine hours (2.4-3.5 hr/day) prevailing during this period are very conducive for disease development.

Phytophthora capsici is soil-borne and infects leaves, stems and roots. Leaf, stem and root infections may occur either individually or they may occur in different combinations. Leaf infection is more severe in areca-black pepper mixed cropping system. It is also seen in pure crop where micro-climatic conditions such as heavy shade and high humidity are congenial for foliar infection. Root and Collar infections (foot rot) are more serious in pure plantations.

Symptoms

Foliar infection: Leaf infection starts as dark brown spots and enlarge rapidly with a fast advancing margins. One to two large leaf spots with a concentric zonation with a greyish centre occupy major portion of the leaf. The infected leaves drop off

prematurely. Infection of spikes results in spike shedding. Tender aerial branches are also infected resulting in rotting and the foliage beyond the point of infection, dries up giving a 'die-back' symptom. Foliar infection starts first on the tender shoot tips/leaves of runner shoots arising from the base of peper vine and spreading on the soil. The infected portion of the stem/leaf produces abundant sporangia and the inoculum gets dispersed to the adjacent leaves through rain splashes. The infection which start at the base of the vine gradually spreads to the upper regions of the vine in a ladder-wise manner through rain splashes. Severe foliar infection results in heavy defoliation. Abundant leaf fall around the base of the infected vine is a common sight in disease affected garden. Occassionally severely defoliated vines will also get collar infection. However, some vines will revive.

Root infection

With build up of soil moisture, Phytophthora multiplies faster and infects the freshly regenerated feeder root systems. This gradually leads to decline and foliar yellowing symptoms. The speed of the death of the vines is determined by the amount of root rot. Feeder root rot gradually spreads to larger roots and ultimately reaches the stem. Root rot ultimately culminates in foot rot. This might take 2-3 years.

Collar (foot) infection

Apart from root rot culimnating in collar rot, independent, collar or foot rot is also noticed. The infection starts as dark patch on the stem at the ground level (collar). Later, rotting of stem sets in and spreads to underground portion of the vine. During earlier stages of collar infection, foliar yellowing appears, and gradually intensifies. In advanced stages of disease development due to stem rot the upward translocation of water and nutrients gets impeded. The aerial tender stems break off at nodal region and drop off. The leaves appear flaccid and show drooping symptoms. Occassionally even without foliar yellowing,

sudden drooping of the foliage is noticed resulting in complete wilting of affected portion of the vine. From the main stem, infection progresses to roots also, resulting in root-rot. From runner shoots, infection occassionally reaches the main stem leading to collar infection. Collar (foot) rot is always fatal and the infected vine succumbs in 20-30 days and hence it was earlier named as quick wilt.

Chemical control

Treat the vine prophylactically as follows:

1. Spray the vines with Bordeaux mixture (1%), drench the basins with 5 litres or more of copper oxychloride (0.2%) during May, June and August-September. The quantity of the fungicidal solution for drenching depends upon size of vine. If the North East monsoon continues longer ensuring high soil moisture, it is essential to go for third round of soil drenching with copper oxychloride. Focus the spray on to the collar region to ensure deposition of spray fluid. This would check collar infection. Depending on the receipt of early monsoon showers, time the first spray coinciding with maximum foliage emergence.

2. Ridomil-Mancozeb (1.25 g/l-100 ppm Metalaxyl) or Aliette (2.5 g/l - 200 ppm) or Akomin 40 (2 ml/l) or Phosjet-40 (2ml/l) can be given both as a foliar spray and soil drench once, skipping one of the above treatments. The systemic fungicides should not be used beyond August to avoid possible hazards of pesticide residues. Indiscriminate use of systemic fungicides is hazardous since fungus may develop resistance to fungicides.

3. Application of phorate @ 30 g/vine, twice, once during May-June and again during August-September to suppress menatodal infection.

Chemical control measures would be ineffective if they are not carried out in time.

Disease resistance

1. Cultivars viz. Narayakodi, Kalluvally, Uthirankotta and Balankotta are identified as tolerant to Phytophthora. Planting of a single variety is discouraged and a varietal mixture of tolerant types is the suggested strategy. Pournami has been released as resistant to root knot nematode.

Future strategies

1. Evolving cultivars with a high degree of resistance and good productivity, transfer of resistance in Piper colubrinum to productive black pepper types through genetic engineering.

2. Developing delivery systems to use VAM (Vesicular arbuscular mycorrhiza) to suppress root infection.

3. Suppression of Phytophthora through organic soil amendments and also through native antagonists hyperparasites which are compatiable with effective agro-chemicals.

4. Inducing host resistance through host nutrition and other means.

Slow decline disease

This is a complex disease involving plant parasitic nematodes (Meloidogyne incognita, the root knot nematode, Radopholus similis the burrowing nematodes and Trophotylenchulus piperis), fungi (Fusarium sp., Rhizoctonia solani), nutritional deficiency coupled with soil moisture stress. The affected plants show root rot associated with nematode infection. Burrowing nematodes feed extensively on feeder root systems and such pepper vines show degenerating root system. Foliar yellowing of the affected vines

start from October and reaches its peak during April, when the soil moisture stress is severe. Degenerating root system gradually impedes absorption and translocation, coupled with moisture stress results in declining symptoms. However, with onset of next monsoon with fresh root regeneration, the vines revive. Root loss to root regeneration balance determines the speed and death of the vine over a period. Recent studies carried out showed that P. capsici also causes feeder root damage and as such there is no clear cut spatial demarcation of nematodes and Phytophthora under field conditions. It is also suspected that what we observe as slow decline, is only a phese of root infection caused by P. capsici that culminates in foot rot. The nematodal infection further accentuates root rot. There is a need to standardise methods which can suppress P. capsici and nematodes involved in this disease complex. Severity of foliar yellowing symptoms are reduced by nematicide application thus giving an indirect indication of the role of nematodes. It is also necessary to check for presence of plant parasitic nematodes in a garden before resorting to nematicide application. However, in general, nematode infection is noticed in majority of the gardens.

III. INTEGRATED DISEASE MANAGEMENT

Any single method is ineffective in checking the disease. Hence an integrated disease management involving host resistance, chemical, cultural and biological methods is an ideal strategy to combat this disease. Following are the proven measures for effective disease management.

Cultural methods

1. Start plantation with disease free rooted cuttings.

2. Phytosanitary measures: Remove all the infected vines along with root system from the plot and burn.

3. Drench the soil with 1% Bordeaux mixture or 0.2% copper oxychloride solution at the infected spot to check soil borne inoculum.

4. Avoid water stagnation and provide good drainage in plantation. Practice minimum tillage concept to avoid root injury to vine during inter-cultural operations like digging etc. Lop off the standards (supports) during May to ensure better light penetration, and to reduce high humidity build up in a garden.

5. Retain legume or grass cover to check the soil splash and consequent infection.

6. Prune off the runner shoots lying on the ground or tie back to the standard to reduce chances of foliar infection and spread.

7. Apply neem cake as a soil amendment that helps in checking both plant parasitic nematodes as well as Phytophthora.

8. Avoid replanting during the same year of vine death. Burn the pit 15 days before planting. Replant only after an year, with fresh disease free rooted cuttings.

'Pollu' disease: (Anthracnose)
(Causal organism: Colletotrichum gloeosporioides)

The fungus infects leaves causing angular brownish leaf spots with a chlorotic halo. The infected berries show brownish sunken cracks. When infected in early stages, further berry development is arrested.

A new type of anthracnose is noticed in high attitudes areas like Coorg district of Karnataka and Wynad district of Kerala. Minute brownish leaf spots occur on leaves, spikes and tender stems. The leaf spots might attain size of 6-8 mm, circular in shape with a chlorotic halo. When the disease is severe with

several spots, affected leaves show crinkled appearance. Tender leaves and spikes are more susceptible and infection results in heavy spike shedding during June-July. When infection occurs on semimature berries their subsequent development is hampered. The disease is caused by Colletotrichum sp. Bordeaux mixture spray during May-June gave excellent control in some of the plantations in Coorg district of Karnataka.

Control measures

Spraying the vines with 1% Bordeaux mixture during June against Phytophthora infection also checks the disease. A combination spray of Ekalux (0.1%) and Dithane Z.78(0.2%) during September was effective in checking both 'Pollu' bettle and 'Pollu' diseases.

Bacterial leaf spot
(Casual organism: Xanthomonas campestris pv betlicola)

The disease is noticed in black pepper gardens in Trivandrum especially in plantations adjacent to betelvine gardens, since betelvine is also infected by this bacterium.

Symptoms

The leaf spots appear as angular, transluscent and water soaked on the lower side of leaf. These lesions turn necrotic later and appear on upper surface of the leaves surrounded by mild chlorotic halo. Severe foliar infection results in premature defoliation.

Since this is a minor disease, no detailed studies were carried out on its control. Even though chloromphenicol (100 ppm) was found to inhibit the bacterium, antibiotic spraying is not recommended. However, 1% Bordeaux mixture spraying might check the disease. It is essential to avoid runner shoots as planting material from disease affected gardens.

IV. DISEASES OF UNKNOWN ETIOLOGY

i. Stunted (Little leaf) disease

A disease which is locally called as 'little leaf' of black pepper is on the increase both in Idukki and Wynad districts of Kerala. This disease was first recorded in the pepper nursery and in the orchard of District Agricultural Farm at Neriyamangalam during 1975.

Symptoms

The affected plants exhibit shortening of internodes to varying degrees. The leaves in this affected branches appear very small, and narrow, sickle shaped, thick and leathery with chlorotic spots/streaks. The affected shoots appear as bunches of small leaves (witches broom appearance). In a single vine both healthy and infected shoots are also noticed. Some of the cuttings raised from infected shoots, also exhibited disease symptom indicating the systemic nature of the disease and the transmission of the disease through cuttings. Association of leaf hoppers and thrips with infected plants is noticed. The disease is suspected to be caused by a virus or mycoplasma like organisms (MLO's). However, the etiology of the disease is yet to be understood.

ii. Phyllody disease

This is another disease which was recorded in Puthady and Naduvayal areas of Wynad district during 1986. This appears to be slightly different from 'little leaf' disease. The affected vines exhibit varying degrees of malformation of spikes and flowers. The stalk of the affected spike elongates considerably compared to that of healthy. The floral buds in the spike showed varying degrees of abortion and transformation into narrow leaf like structures giving the appearance of a brush. The leaves also become small and chlorotic and occasionally tufts if leaves are

noticed. The flower buds also develop into small vegetative branches resembling the fruiting laterals with nodes and internodes with narrow leaf like structures. The tender berries appear oval in the infected vine compared to round healthy berries. The affected vines showed general foliar yellowing. However, some of the affected vines showed normal foliage and spikes.

Electron microscopic studies revealed presence of mycoplasma like organisms (MLO's) in the phloem cells of affected spikes indicating mycoplasmal etiology of the disease. The affected plants showed association of thrips and leaf hoppers. However, their role in the transmission of the disease is yet to be understood. Detailed studies are warranted to understand etilogy of the disease.

Control

In view of their increased incidence and lack of information on the etiology of these two new diseases, it is practical to eradicate infected vines to check their further spread. Since the disease is noticed only in some pockets it is easy to eradicate before they attain severity.

Thus correct identification of the disease problem, timely adaptation of effective disease management strategies are essential to check the crop losses, and to boost up the pepper production.

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DISEASES OF GINGER, TURMERIC AND THEIR MANAGEMENT

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Ginger and Turmeric are the most important commercial spice crops grown in India. Ginger is known for its medicinal value besides a spice. Whereas turmeric is mostly used in culinary, as colouring agent, flavour and in cosmetic industries. These two crops are affected by a number of fungal and bacterial diseases.

1. GINGER

Rhizome rot/Soft rot

Causal organisms : *Pythium aphanidermatum*, *P. myriotylum*, *P. vexans*

Rhizome rot is of common occurence in all ginger growing tracts in India. Severe loss up to 80-90% are reported.

Symptoms: Infection is seen in sprouts, leaves and pseudostems. The disease manifests on the leaves which turn pale green to yellow. The yellowing starts from margins which gradually spreads to entire lamina. The yellowing is followed by withering and drying up of leaves. Water soaked lesions develop on pseudostems. Soft rot extends from collar region to the rhizomes which first become discoloured and gradually decompose forming a water mass of putrefying tissues enclosed by a tough ring of rhizome. The fibrovascular strands are affected which turn black in colour. The roots of infected plants undergo rotting and softening. Besides damage in the field, rotting is also noticed in the rhizomes collected from infected crop and kept in storage. The disease is wide spread in fields where rainfall is high with poor damage facilities.

Survival and spread of the pathogen: The pathogen is both soil and seed borne. The fungus survives in diseased rhizomes and also through the resting structures present in soil.

High soil moisture with high humidity and low temperatures are condusive for disease development.

Management:

1. Select healthy seed rhizomes from disease free areas.
2. Treat seed rhizomes with Dithane M-45 (0.3%) immediately after harvest and before sowing.
3. Phytosanitary measures like rouging and burning infected plants
4. Avoid waterlogging conditions
5. Follow crop rotation practices
6. Drench infected beds with either Dithane M-45 or copper oxychloride.

Bacterial Wilt

This is a serious disease in ginger growing tracts, It was reported from almost all ginger growing tracts.

Causal organism: Pseudomonas solanacearum

Symptoms: The first visible symptom is the flaccidity of leaves resulting in curling ie., leaves fold backwards and wilt as if it is suffering from moisture stress. At the base of affected pseudostem/tillers, a greyish black discolouration is seen. This will be followed by yellowing and withering of plants. When affected pseudostems and rhizomes are cut and pressed, a milky ooze comes out from cut ends. Water soaked lesions also develop on the pseudostems at base. If infected pseudostems are cut and kept in clean glass of water, the water becomes turbid because of exudation of bacterial ooze coming out of cut ends.

Survival and spread: The pathogen survives through infected rhizomes and many other weed hosts such as Chromolina, Ajeratum etc. The pathogen has very wide host range including almost all solanaceous crops.

Management:

1. Crop rotation
2. Seed treatment with (200 ppm) streptocycline solution
3. Selection of healthy seed material

Leaf spot of Ginger

Causal organism: Phyllosticta zingiberi

Symptoms: Initial symptoms are observed as small, yellowish, oval to elongated spots on leaves . The spots vary in size from 0.5 mm to 1 m. These spots enlarge, coalesca forming big lesions. The central portion of the spot becomes papery, white and the margins become dark brown with a yellow halo. In case of severe infection, all leaves become involved and discolouration can be noticed from a distance. The central papery portion falls off ultimately leaving a shot hole.

Survival and Spread: Leaf debris form the source of survival of the organism. Rain splashes spread the disease.

Management: Spray Dithane M-45 or
Dithane Z-78 (0.2%)

Yellow disease

Causal organism: Fusarium oxysporum
F. solani

This disease has been reported from Himachal Pradesh, Orissa and Karnataka.

Symptoms: The disease manifest on the leaves as yellowing of the two margins of the lower leaves which gradually spreads covering entire leaf. Older leaves dry up first followed by younger ones. Plants may thus show premature drooping, wilting, yellowing and drying of plants in patches. However, plants do not topple over to the ground. The basal portions of the affected plant become soft and watery. Stunting of plants is a common symptom. In rhizomes a cream to brown discoloration accompanied by shrivelling and rotting is seen. Roots rot and rhizome formation is affected. In the final stages of decay, only the fibrous tissue remains within the rhizome. A white cotton fungal growth may also develop on the surface of stored rhizome.

Perpetuation and Spread: The disease perpetuates through infected rhizomes and spreads through soil. It is both soil and seed borne disease.

Management:

1 Seed treatment with Dithane M-45 (0.3%) or Bavistin followed by drenching twice at the time of sowing and 15 days after sowing

2 Crop rotation

3 Selection of healthy seed materials

Mosaic of Ginger

Causal organism: Wheat streak mosaic virus

Symptoms: The first visible symptoms is appearance of chlorotic flecks which later change to spindle shaped chlorotic streaks of discontinuous nature running parallel to each other from mid rib to margin. Several such streaks may coalesce forming larger yellowish strips. With the advancement of the disease, yellowish strips together with green areas form a mosaic pattern. In some cases, dark green and light green patches seen parallel from mid rib to leaf margin.

Management:

1. Rouge out infected plants and brun them immediately
2. Give a spray with any insecticide to present spread of the disease spreading vector

II. TURMERIC

Leaf blotch of turmeric

Causal organism: Taphrina maculans

Leaf blotch is prevalent in all the turmeric growing areas.

Symptoms: The disease is identified by the appearance of a large number of spots on both sides of leaves, being generally more numerous on upper surface. The spots appear as pale yellow in colour initially which turn to dark brown. The spots are usually small, 1-2 mm in size and coalesce freely to cover entire leaf area. In case of severe infection, hundreds of spots are seen, reddish brown in appearance with necrotic blotches leading to the drying up of leaves. Farmers do not consider it as a serious disease but excessive spotting causes destruction of assimilative tissue leading to drastic reduction in yields.

Preparation and spread

Infected dried leaves form source of survival. Cool humid conditions are conducive for the spread of the disease.

Management:

1. Use of disease resistant varieties
2. Spray Dithane M-45 or Dithane Z-78

Rhizome rot of Turmeric

Causal organism: Pythium graminicolum
Pythium aphanidermatum

This is the most dreaded disease on turmeic prevalent in all the growing areas.

Symptoms: The disease appears in patches in the field. The leaves of the infected plants becomes yellow and exhibit gradual drying along the margins. Water soaked lesions develop on the pseudostem and becomes soft to touch. The root system is adversely affected. Roots rot completely. As the disease progress, infection gradually spreads to rhizome which begins to rot and becomes soft to touch and hence the disease is called soft rot. Infected rhizomes turn to brown in colour. In case of severe attack, yield is considerably reduced.

Preparation and spread: The disease is both seed as well as soil borne. Pathogen survives in the infected rhizomes and spreads through soil

Management:

1. Crop rotation
2. Selection of health rhizomes from disease free areas
3. Seed treatment with Dithane M-45 after harvest and before sowing
4. Roguing infected plant materials
5. Drenching infected beds
6. Avoid water logging conditions.

Leaf spot of turmeric

Causal organism: Colletotrichum capsici

This disease is more prevalent in Tamil Nadu and Andhra Pradesh. Losses up to 50% have been reported.

Symptoms: Infection is usually confined to leaf blades and occassionally extended to leaf sheath also. Disease appears as elliptic to oblong spots of variable size on both surfaces, but more on upper surface. These spots gradually enlarge in size and

coalesce to cover entire leaf area to form large necrotic patches. The spots very from 4-5 cm in lengh and 2-3 cm in breadth. A fully developed spot has a greyish white centre with brown margin surrounded by yellowish in defined halo. In severe infection leavs dry up and defoliate.

Preparation and spread: Infected leaf debris left in field form source of survival of pathogen. Dissemination is by air. Cool humid conditions are favourable for disease development and spread.

Control: Spray Bordeaux mixture (1%) or any other copper fungicides

Storage rots

Causal organisms: Aspergillus sp. Macrophomina phaseolina, Alternaria sp. Fusarium solani, F. monliforme, Memnoniella sp. Sclerotium rolfsii and Diplodia sp. Besides above fungi, certain soil brone plant pathogens are also known to cause storage rots. Among bacteria Erwinia carotovora and Pseudomonas solanacearum were found to cause storage rots.

Ginger and Turmeric rhizomes are kept for storage immediately after harvest for 3 to 6 months, before sowing. During this storage period, rhizomes are invaded by fungi causing deterioration and heavy loss. Some of them are pathogenic while others are saprophytic in nature, Germination of such infected rhizomes comes down drastically. If the rhizomes are kept in poorly ventilated conditions, the chances of rotting is more.

Management:

1. Phytosanitation - cleaning of rhizomes after harvest
2. Air drying under shade will reduce moisture content and there by invasion of fungi
3. Seed treatment with Dithane M-45 after harvest and before sowing will reduce storage rots considerably.

Other diseases

Besides above, some minor disease are recorded on ginger and turmeric. However, these are not predominant all over the country.

Leaf spots

Leaf spots caused by Helminthosporium, Pyricularia zingiberi, Leptosphaeria zingiberi and leaf blights caused by Rhizoctonia solani, thread blight by Pelliculoria filamentosa.

Control: Spray with any copper fungicide.

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DISEASES OF TREE SPICES

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Clove, nutmeg, cinnamon and allspice are a few of the tree spices cultivated in India. In general, diseases are less in number in these crops. Although, clove is a host of pathogens causing sudden death, slow decline etc. in other countries, in India a few diseases are only recorded. The important diseases occuring on tree spices and the control measures are:

Clove

1. Leaf rot:

This disease is caused by the fungus Cylindrocladium quinque-septatum. Dark patches appear on the leaf lamina which gradually spread and cause severe defoliation and in extreme cases, cause dieback of branches. This occurs during rainy season. During wet weather, the fungus produces conidia on the lower surface of affected leaves which are spread by rain splashes. Prophylatic sprays with Bordeaux mixture (1%) prevents the disease.

2. Seedling wilt:

Seedling mortality up to 40% is also recorded. Affected seedlings lose the lustre on the leaves and become flaccid. Discolouration of tissues at the collar region and rotting of roots are other symptoms. Several fungi are reported to cause seedling wilt. Rhizoctonia, Cylidro-cladium and Fusarium are the

commonly-associated organisms. Raising nursery in fumigated soil and fungicidal treatment in nursery are the recommended control measures.

3. Little leaf:

This disease is characterised by the stunted growth of plants and reduced size of leaves. The canopy becomes cone-shaped due to production of branches at acute angles to the main stem. Primary and secondary branches become closely arranged and become shorter towards periphery of the tree. The affected trees fail to flower. This disease is suspected to be a virus disease.

4. Leaf spots and bud shedding:

Reddish brown to dark brown spots with a yellow halo appear on leaves. This is caused by Colletotrichum crassipes. Occasionally, such spots also appear on the buds causing shedding of buds. Prophylatic spraying with Bordeaux mixture (1%) prevents both the diseases.

Nutmeg

1. Fruit rot and fruit drop:

The fungi viz. Phytophthora sp. and Diplodia natatensis are involved. The infection starts from the pedicel end as dark water soaked lesions and spread gradually downwards causing discolouration of rind and rotting. In advanced stages, the mace and nut also become infected. In certain cases, immature nut splits and greenish sunken lesions are also noticed on immature nuts. Control measures include phytosanitation and spraying with Bordeaux mixture (1%).

2. Leaf rot and shot hole:

Dark brown spots with a chlorotic halo are formed on leaves which later become dry and fall off leaving a hole, hence the name 'shot hole'. Colletotrichum sp. and Cylindrocladium sp. are the fungi causing this disease. Injuries on leaves are found to be a pre-requisite for infection by Colletotrichum. Prophylactic spray with Bordeaux mixture (1%) checks this disease.

3. Thread blight:

Two types of thread blights are noticed in India - white thread blight and horse hair blight. In both cases, thread-like hyphal aggre-gation traversing along the stem and ventral side of leaves spreading in a fan-shaped or irregular fashion. The infected leaves are blighted and remain attached to the stem by the fungal mycelia. Thread blights are usually seen under abnormal wet conditions. Heavy shade and lack of proper drinage help the fungal growth. Marasmius spp. and Corticium sp. are the two fungi causing this disease. It is controlled by adopting phytosanitation and spraying Bordeaux mixture (1%).

4. Die back:

This is caused by the fungus Diplodia notalensis. Infection occurs at the terminal parts of the branches which gradually spread downwards. Spraying with Bordeaux mixture (1%) controls this disease.

Cinnamon

Leaf spot and shot hole:

The infection starts as irregular grey patches on leaves. The infected portion dries up and drops off. Pestolotia cinnamomi is reported as the causal organism. Gloeosporium is also isolated

PLANT PARASITIC NEMATODES OF BLACK PEPPER AND THEIR MANAGEMENT

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Black pepper (Piper nigrum L.), one of the major foreign exchange earning crops, is grown mainly in Kerala and Karnataka. Role of plant parasitic nematodes in black pepper cultivation gained importance because of their involvement in 'pepper yellows' in Indonesia and Malaysia and 'slow decline' (slow wilt) in India, a major constraint in black pepper production. Information on crop losses due to the nematode diseases in black pepper is very much limited except a few historic reports. The burrowing nematode Radopholus similis, responsible for 'pepper yellows' caused the death of 22 million vines in Bangka Islands of Indonesia over a short period of two decades. In Guyana also, about 30 per cent of the vines were damaged by a similar disease called 'yellows' due to nematode infestation. Experimental ovidences showed that yield of black pepper can be increased by 50 per cent by controlling nematode infestation by application of nematicides. Besides these, no efforts were made to estimate actual loss in yield due to nematode infestation in black pepper.

Plant parasitic nematodes associated with black pepper :

Though 48 nematode species belonging to 29 genera were reported on black pepper, only 17 genera were reported from Kerala and Karnataka. A detailed survey conducted by National Research Centre for Spices, Calicut, in all the major pepper growing areas in Kerala and Karnataka revealed association of 14 genera of plant parasitic nematodes which include two endoparasitic forms viz., Meloidogyne incognita (root-knot nematode), R. similis (burrowing nematode) and a semi-

from infected leaves. Seedling blight by Diplodia sp., leaf spot by Cephaleuros sp. and leaf rust by Aecidium cinnamomi are reported.

Allspice

Leaf rot and die back:

Two fungi are associated with leaf rot viz. Cylindrocladium quinqueseptatum and Pestalotiopsis sp. Infection leads to severe defoliation and in advanced cases leads to die back of branches. In case of Cylindrocladium infection, the margins of lesion are diffuse and white downy sporulation occurs on the lower surface of infected leaves. In case of Pestalotipsis infection, the margins of lesion are demarcated by a dark-brown advancing margins and sporulation of the fungus appear as black spots on the surface of the lesions. Both could be controlled by spraying with Bordeaux mixture (1%) at the onset of monsoon season.

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endoparasitic nematode Trophotylenchulus piperis. These three nematode species are the major nematodes infesting black pepper. More than 40 per cent of the root samples examined were infested with M. incognita / R. similis. High population of M. incognita (more than 1000 nematodes per gram of roots) and R. similis (more than 250 nematodes per gram of roots) were found in more than 25 per cent of the root samples indicating severity of the nematode problem on black pepper in India.

The other nematode species recorded on black pepper are Acontylus sp., Aphelenchus sp., Criconemoides sp., Helicotylenchus sp., Hoplolaimus sp., Longidorus sp., Pratylenchus sp., Rotylenchulus reniformis, Scutellonema sp., Tylenchorhynchus sp., and Xiphinema sp.,

Symptoms :

Generally nematode infested plants exhibit common symptoms on the above ground plant parts which do not permit positive early diagnosis. Slow decline of black pepper is a debilitating disease affecting pepper vines slowly over a period of three to five years. The characteristic symptoms of the disease are foliar yellowing, defoliation, die back, loss of vigour and productivity, gradually leading to death of the vine. The root system of the diseased vines show varying degrees of root knots, necrosis, rotting and disintegration. In severe cases, feeder roots are completely destroyed. Some of the diseased vines recover with the onset of monsoon. However, majority of diseased vines show varying degrees of disease symptoms throughout the year.

Meloidogyne incognita (Root-knot nematode) :

These are sedentary obligate endoparasites which evolved a very specialised and complex relationship with host plants. The second stage juveniles of the nematode enter root near the root tip region and subsequently develop into adults. The nematode

causes hypertrophy (enlargement of cells) and hyperplasia (excess cell multiplication) resulting in formation of galls or knots on roots. In the thick primary roots, adult females with egg masses are situated deep below the epidermis, hence the galls appear smooth. Root knot nematode feeds on vascular tissues resulting abnormal vessel elements and destruction in the arrangement and continuity of vascular tissues affecting absorption and translocation of water and nutrients. This affects growth and productivity of vines.

Radopholus similis (Burrowing nematode) :

It is a migratory endoparasite and feeds on critical tissues. The nematode enters generally at the root tip region and moves inter and intra cellularly in the cortical tissues. All stages of the nematode are found in the root. Elongate brownish lesions develop on the root at the site of nematode entry. When the infestation is severe, many such lesions coalesce leading to typical root necrosis and rotting. The affected vines exhibit severe growth retardation and foliar yellowing.

Pathogenic effect of plant parasitic nematodes on black pepper :

Experiments conducted under artificial inoculation in pot culture showed varying degrees of reduction in the growth of pepper vines due to M. incognita and R. similis. However, in all these studies, the actual loss in yield could not be estimated due to the fact that these experiments were conducted in pot culture on young vines only for a short period.

Pathogenicity experiments to study the effect of M. incognita and R. similis individually and in combinations on growth and productivity of pepper vines conducted under simulated field conditions showed that both the nematode species caused significant reduction in growth, vigour and productivity. More than 45 per cent reduction in the yield was recorded in vines

inoculated with higher levels of M. incognita and R. similis. R. similis caused maximum damage to vines resulting in the lowest yield compared to M. incognita. Further the vines inoculated with R. similis alone or in combination with M. incognita exhibited symptoms such as foliar yellowing, defoliation and die back, typical of slow decline.

Besides causing damage to pepper vines in the plantation, these nematodes also cause considerable damage to rooted cuttings in the nursery. Damage caused to roots by nematode infestation results in poor growth and foliar yellowing, and establishment of such cuttings will be poor when field planted. Rooted cuttings even with mild infestation by nematodes when planted in the field will gradually lead to slow decline at a later date.

Seasonal fluctuations :

Population of plant parasitic nematodes in the roots of black pepper varies during different seasons with definite trend. R. similis population is at the lowest level during April/May which gradually increases from June/July reaching to the highest level during September/October. Root knot nematode population starts increasing from the month of May reaching its peak during December. Fluctuations in the nematode population are influenced by rainfall and subsequent effects on soil moisture, soil temperature and root regeneration of host plant.

Nematode management :

Use of chemicals has been one of the important components in the control of nematodes in various agriculture crops. However, high cost, difficulty in handling chemicals, general awareness about environmental pollution, and health hazards due to nematicidal application are a few of the limiting factors in usage of nematicides. Since, total eradication of nematodes in the intensive cropping systems particularly in plantation crops is impossible, it is imperative to adopt an integrated nematode

management involving resistant/tolerant genotypes; cultural practices like application of oil cakes, mulching with green leaves, biological control agents with minimal use of chemicals.

In the absence of effective alternate methods, the following package is suggested in checking the nematode build up.

Nursery :

1. Use fumigated nursery mixture for raising nematode free cuttings. Nursery mixture can be fumigated either with *methyl bromide (MBr) @ 500 g/100 cft of soil or drenching the soil mixture with 2 per cent formalin under* polythene cover for 48 hours. After 48 hours, remove the polythene sheet, rake the soil to liberate excess poisonous gas of the chemical. This mixture can be used for planting after 2-3 weeks.

2. Addition of VAM to the nursery soil mixture can help in reducing nematode infestation in rooted cuttings.

3. A prophylactic application of nematicide is also necessary to check nematode infestation. For this, make three equidistant holes of 2-3 cm deep in the bag around the cuttings and place phorate @ 1 g/bag or carbofuran @ 3 g/bag in these holes and cover. A light irrigation may also be given to ensure adequate soil moisture.

Plantation :

1. Plant root-knot nematode tolerant variety 'Ottaplackal-1' where this nematode is a major problem.

2. Nematode free rooted cuttings raised in fumigated soil mixture should be used for planting.

3. Remove severely affected vines which are beyond recovery.

4. Treat the pit with phorate @ 15 g or carbofuran @ 50 g at the time of planting.

5. Apply neem cake @ 2 kg/vine to check nematode build up.

6. Apply phorate @ 30 g or carbofuran 100 g/vine twice in an year. First application during May/June with the onset of South-West monsoon and second application during September /October.

Rake soil in the basin of the vine lightly without causing damage to roots, spread the nematicide uniformly in the basin and cover it with soil immediately. Sufficient soil moisture should be ensured at the time of nematicide application.

It is better to take up control measures in the early stages of the disease development.

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DISEASE AND PEST MANAGEMENT IN CARDAMOM

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Cardamom (Elettaria cardamomum Maton) is a perennial herb belonging to Zingiberaceae. The dried seeds or entire seed pods are used as a spice to flavour curries, sweets, cakes, breads and coffee.

The environment of cardamom growing areas is characterised by perennial overhead shade canopy, heavy rain fall and cool humid conditions. The perennial herbaceous nature of this rhizomatous crop provides congenial conditions for incidence of many diseases and pests right from sowing to bearing stage. Among disease of small cardamom, 'katte" or mosaic disease caused by poty virus and 'Azhukal' disease caused by Phytophthora sp. are the most serious causing heavy crop losses. Nursery leaf spot by Phyllosticta elettariae, damping off and rhizome rot caused by Pythium vexans and Rhizoctonia solani, leaf blotch, Vythiri spot capsule, chenthal etc. are on increase in recent years. Many of the diseases are little known and a few of them are of minor importance.

1. 'Katte' or mosaic disease:

This disease is prevalent in all cardamom growing areas. The disease incidence is more in Karnataka and it is comparatively less in Kerala and Tamil Nadu. The losses in yield depend on stage and duration of infection and it varies from 10-98%.

Clear mosaic symptoms are seen on young leaves in the form of short to long alternate stripes of light green and dark green areas arranged parallel to one another. Often mottling is seen on leaf sheath and young pseudostems. As leaf matures, the mosaic

symptoms are more or less marked. Infection is systemic and it spreads to all tillers in a clump. Younger seedlings express symptoms earlier than grown up plants. Infected plants are small and produce slender tillers with shorter panicles. Plants never die due to 'katte' infection but survive for years and serve as sources of inoculum.

The disease is caused by non-persistent virus, classified under 'poty virus' group. It spreads through aphid vector Pentalonia nigronervosa f. caladii and also by use of infected planting material. All stages of aphid transmit the disease and it is not transmitted through soil, seed or mechanical contact. All commercially grown cardamom cultivars are susceptible to the disease.

Disease management

In new plantations healthy seedlings raised from high yielding plants are used to raise seedlings. Use of voluntary seedlings or clones from infected plantations should be strictly avoided. All the plants should be examined periodically atleast twice a year to detect and eliminate 'katte' infected plants.

In established plantations, rouging may be adopted as a means of disease management, if the disease is less than 10% only. The affected plants are to be removed and destroyed promptly and further, the surveys are to be repeated at monthly or bimonthly intervals depending on disease incidence. In severely infected plantations, roguing and also maintaining the infected plantation are uneconomical. In such areas, replanting either as a whole or in a phased way followed by regular surveys to rogue out fresh infections is more appropriate.

'Azhukal' or capsule rot

(Causal organism(s): Phytophthora nicotianae var nicotianae P. meadii, Pythium vexans)

This is the second most serious disease of small cardamom and is prevalent in cardamom hills of Idukki and a few parts of Wynad and Anamalais (Tamil Nadu). Azhukal in malayalam means rotting and disease results in extensive rotting of capsules. During years of heavy and continuous rainfall, losses upto 50% are noticed. Usually the disease starts with August-September and continues to prevail upto December if the weather is favourable. Disease is seen on all aerial parts and all the three types of cardamom are susceptible.

Panicles and capsules are the major targets of infection because of their proximity to soil, which is the main source of infection. The panicles and capsules of all stages of maturity are infected. The affected tender capsules fall off within 2-5 days while matured capsules get shrivelled on drying. The panicle beyond the point of infection dires up. Infection on unopened leaves appears as water soaked lesions which later enlarges resulting in decay or shredding of leaves.

Disease management

Integration of both cultural and fungicidal management practices is very important for effective management of disease. Cultural practices include phytosanitation i.e. removal and destruction of affected parts, regulating excess shade and trashing to remove senile parts to allow better light, penetration.

Spraying Bordeaux mixture (1%) or Copper oxychloride (0.2%) with wetting agent is effective in reducing disese incidence. First round of spraying and drenching around the plant basin should be done in May-June before the onset of monsoon. The

second spray is given in the early August, when there is break in the rain and a third round may be given in September if the monsoon is prolonged and disease is still persistent. Phytosanitation coupled with three rounds of Bordeaux mixture spray during May, June and July, reduced disease incidence to 5.74% compared to 36.27% in control. Soil amendments with neem oil cake also reduce soil borne initial inoculum and active fungal antagonists.

Damping off and rhizome rot disease
(Causal organism: Pythium vexans, Rhizoctonia solani)

This disease is seen both on young seedlings and mature plants and take heavy toll in the (i) old nursery sites (ii) ill drained valley bottoms (iii) high rainfall zones. Incidence upto 64.5% was recorded in the old nursery sites and rhizome rot upto 47.0% was recorded in plantations.

In seedlings, the disease is found in both primary and secondary nurseries and it is called damping off and later rhizome rot. Infection in plantations is commonly called clump rot or the rhizome rot. In nurseries, infection is seen on collar region of seedlings. The collar region rots and this is followed by wilting of leaves and seedlings collapse in patches. In older seedlings, rhizome and roots decay resulting in total death of seedlings.

In plantations, the disease makes its appearance in the form of pale yellowing of foliage and premature death of older leaves followed by general wilting of affected tillers. The affected tiller breaks off at collar region even with slight disturbance. As the disease advances, symptoms of rotting develops on adjacent tillers and they fall off radially.

Disease management

i. Nurseries: In older nursery sites, with previous history of disease, pre-sowing treatment of nursery beds with 1:50 formaldehyde @ 10-15 l/sq metre under polythene cover minimises

effectively soil borne inoculum. As the fungicidal application is less effective after noticing infection prophylactic drenching with copper oxychloride (0.2%) has to be taken imediately after germination. Thin sowing and good drainage are the other important pre-requisites to minimise infection.

ii. Plantations: Cultural practices like removal and destruction of infected plants, regulating excess shade to allow 50-60% sunlight, good drainage and three rounds of trashing (one each in June, August and October) help in reducing severity of rhizome rot.

Drenching basins of plant with copper oxychloride (0.2%) or Bordeaux mixture (1%) @ 2-3 litres/plant helps in reducing disease severity by 49%.

Nursery leaf spot

(Causal organism: Phyllosticta elettariae)

It is the most destructive disease in cardamom nurseries and often poses serious threat to successful raising of seedlings. The disease is noticed in February-April with receipt of showers and becomes serious during monsoon from June-August.

The disease commences as minute water soaked spots on undersurface of leaves and later turns into necrotic spots surrounded with water soaked areas. If wet weather prevail, these spots gradually enlarge and result in blighting or rotting of entire leaf. During dry period, spots remain more or less circular in shape, greyish in colour with numerous black pycnidia. Infection on primary seedlings results in extensive rotting or death of plants and seedlings develop tolerance as they grow old. Disease is primarily soil brone and spreads mainly through rain splash.

Disease management

This disease can be controlled effectively by timely spraying Captafol (0.2%) or Bordeaux mixture (1%) or Bavistin (0.2%). First spray is to be applied in March-April depending on summer showers and subsequent sprays at 15 days interval. Integration of cultural aspects like (i) early sowing (September); (ii) avoiding direct sunlight from top or sides; (iii) providing uniform filter shade; (iv) shifting of nursery site; (v) raising nursery in fertile soil with optimum nutritional management, help in achieving better control of nursery leaf spot.

'Chenthal' disease

Suspected causal organism(s):

Corynebacterium sp; Cercospora sp; Colletotrichum gleosporoides

This is a foliar disease and is seen in entire cardamom belt of Kerala, Karnataka and Tamil Nadu. Though the disease is foliar, it has adverse effect on fruit set. Flowers produced in the severely affected plants, fail to set capsules. A decrease in the weight of the capsules with an increase in severity of disease was noticed and yield reduction of 7-13% was seen in Mysore variety.

The disease is generally noticed on second leaf as elongated water-soaked lesions of varying sizes on lower side of leaf. These lesions turn necrotic with yellow halo around. The lesions develop near the margin and progress inwards towards the midrib. As the leaf start drying the pseudostem wilts. The severely affected garden presents a burnt appearance hence the name 'Chenthal'. In plantations, exposed and under shaded areas show severe disease incidence.

Disease management

Very little information is known about control aspects of this disease. However, the plantations receiving organic fertilizers were less infected compared to plantations receiving inorganic fertilizers. Similarly by planting fast growing shade trees in exposed and less shaded areas, the disease severity can be reduced.

Minor diseases of cardamom

Nilgiris cardamom necrosis virus caused by 'Carlavirus', vein clearing virus (Kokke Kandu), leaf blight caused by Phaeodactylium alpiniae, leaf rust caused by Uredo elettariae, leaf rot caused by Phytophthora meadii, seedling rot caused by Fusarium oxysporum, capsule canker suspected to be caused by Xanthomonas sp., and anthracnose or brown spot of capsule caused by Colletotrichum gleosporoides are the diseases of minor importance. The first two viral diseases can be contained by exclusion of virus source and roguing off. Other foliar diseases can be minimised by one or two round of prophylactic spraying with Bordeaux mixture (1%).

Pests of Cardamom

Cardamom is infested by a variety of pests from seedling stage in the nursery to capsule stage in plantation. These enemies range from viruses to vertebrates like squirrels, monkeys and even wild boars.

I INSECT PESTS

More than 72 insect species are recorded on cardamom of which, thrips, shoot and capsule borers are the most important in terms of distribution and economic losses.

1) *Thrips (Sciothrips cardamomi):*

This is the most destructive and persistent pest of cardamom. Adult thrips are greyish brown and complete life cycle in 27-30 days. Both adults and nymphs cause damage to cardamom shoots and all parts of inflorescence. They lacerate surface tissues of capsules and peduncle and suck exuding sap. The injured tissues form a corky layer on surface of capsule and appear as 'scabs' popularly called as 'cardamom itch'. Damage may be extended to flower stalk and this results in shedding of capsules and flowers. 'Mysore' type is more prone to thrips attack. Extent of damage in terms of quality and quantity ranges from 30-80%. Thrips population is higher in post monsoon (September-April) period.

Management

(a) Remove dried parts and shoots in the clump during monsoon and before insecticide spray; (b) spray insecticides like quinalphos, monocrotophos (0.025%) or phosalone (0.07%) or methyl parathion (0.05%) during summer and winter, skipping the heavy monsoon.

2) Shoot, Panicle and Capsule Borer (Conogethes punctiferalis)

This is a very serious pest in nurseries and plantations. The adult is a medium-sized moth of orange-yellow colour, with black spots on wings. It complete life cycle in 25-40 days. Eggs are laid mostly on top leaf axils of young pseudostems. The young caterpillar bores at base of young seedlings and at the nodal regions of grown up suckers and tunnels the shoot, resulting in drying of the terminal leaf and thus produces the characteristic

'dead heart' symptom. The conspicuous oozing out of excreted frass material at mouth of holes is indication of presence of larvae inside the pseudostem. When the panicles and spikes are attacked, further production of flowers on them is stopped and the portion above the point of infection gets dried up. They also bore into the immature capsules and feed on seeds inside, rendering them empty. Incidence of this pest is noticed throughout the year but its population attains peak during September-October.

Management: (a) If infestation is fresh, as indicated by extrusion of frass, collect and destroy affected plant parts; (b) spray fenthion, monocrotophos, quinalphos or endosulphan (0.075%) twice, during January-February and September-October. Spray after picking the crop.

3) Early Capsule Borers or Lycaenid Borer (Jamides sp.)

This pest is distributed widely in Karnataka. The adults with blue wings lay eggs on all parts inflorescence. The caterpillars bore and feed on flower buds, flowers and young capsules. The attacked parts become empty, with a big circular hole, turn yellowish-brown and eventually decay and drop off in rainy season. Emerging larva damages about 25-27 capsules within 18-20 days. Life cycle is completed within 45 days, This pest appears normally during early monsoon, when plant produces fresh flush.

Management: Spray with quinalphos (0.025%) or methyl parathion (0.05%) during early blooming period.

4) Beetle Borer or Scolytid Borer (Ihamurgides cardamomi)

This is a tiny, dark brown, cylindrical beetle with hairs all over the body. Both the adults and larvae damage capsules. Adult bores a single hole per capsule and fine saw dust like frass is thrown out of hole. They feed on the mucilage inside and white

seeds and lay eggs singly. The larvae pupate inside. Damage due to this pest is very high during July-August, particularly in thickly shaded areas.

Management: (a) Regulate shade in thicky shaded areas; (b) spray contact insecticides like quinalphos (0.025%), methyl parathion (0.05%) in March-April and September-October. Spray may be done only after harvest.

5) Hairy Caterpillars (Eupterote spp., Lenodera vittata, etc.)

Several species of hairy caterpillars cause damage in cardamom plants. These appear sporadically in enormous populations at intervals of several years and cause untold havoc by total defoliation of plants. They are gregarious in habit and congregate on trunks of shade trees and then drop on to cardamom plants during night. The adult moths which emerge in June-July lay eggs in masses on undersurface of leaves of shade trees. Eggs hatch in 13 to 30 days and larval stage extends up to 97-150 days with a number of instars. Pupal period lasts 7-8 months. Usually damage is observed during October-December.

Management: (a) Collect and kill caterpillars which congregate at base of shade trees; (b) gradually eliminate shade trees favoured for egg laying; (c) spray any of the insecticides like methyl parathion, quinalphos, etc. (0.1%) or dust with BHC (10%) or Zolone (4%) when the caterpillars start feeding on cardamom.

6) Shoot fly (Formosina flavipes)

The shoot fly maggots feed on growing shoots of young cardamom suckers in new plantations and nurseries causing 'dead heart' symptom. Nearly 50-60% of the clumps are affected. The damage will be more severe in open areas where shade is inadequate. The pest activity starts during November and reaches peak in March-April. The life cycle lasts for 20-25 days.

Management: (a) Remove the affected shoots at ground level and destroy them; (b) spray dimethoate, quinalphos or methyl parathion at 0.05% or apply carbofuran 0.3 kg a.i./acre.

7) White Fly (Dialeurodes cardamomi)

This is a serious problem in some cardamom growing areas of Kerala. The adult fly is a small, soft bodied insect, having two pairs of white wings. The nymphs and adults of insect remain in colonies on lower leaf surface and suck sap. As a result, chlorotic patches appear on leaves. Gradually, leaves turn yellow and get dried, resulting in reduced plant growth and poor yield. Pest infestation is seen maximum during dry months.

Management: Spray insecticides like methyl dimeton, dimethoate or phosphamidon (0.05%) on the foliage.

8) Rhizome weevil (Prodioctes haematicus)

The brown adult weevils lay eggs in the punctures made by it in the exposed portions of rhizomes. The grubs turn into rhizome and cause extensive damage. Life cycle is completed within one year. The pest becomes severe during dry periods (November-January).

Management: (a) Destroy affected plants / seedlings (b) collect adult weevils mechanically and destroy; (c) drench base of clumps with BHC (0.2%) or apply phorate @ 2-4 g a.i./clump.

9) Root Grubs (Basilepta fulvicorne)

Recently this pest is more severe in Karnata and Kerala. Adult beetles are metallic blue, bluish-green or greenish brown and are polyphagous. They lay eggs in soil around root zone. The emerging yellowish white grubs feed on roots and rhizome portion of Cardamom. Mature grubs are short and stout and are 'C' shaped. They pupate in an earthen shell and emerge as adults. The life cycle may be completed within three months depending on weather

conditions. There are two peak periods of adult emergence on soon after the pre-monsoon showers (April-May) and the other during September-October. These grubs feed on cardamom roots in the form of irregular scraping which leads to drying or rotting of roots. Severely affected plants show yellowing and drying. Such clumps lose their held in the soil and fall off.

Management: (a) Collect the adult beetles during peak periods using a nylon net and destroy; (b) apply aldrin (0.1%), BHC (0.2%0 or phorate (2-4 g a.i./plant) in the soil after raking the soil and when there is adequate moisutre. The appliation should be made during April-May and September-October, synchronising with emergence of adults and egg laying.

10) Root Borer (Hilographs caminodes)

The adult moth lays egg on exposed portions of root. The larvae that hatch out bore into root making tunnels filled with frass. The roots start drying from the tip backwards as a result of injury caused by the pest. This leads to yellowing of leaves and weakening of plants. The entire clump may dry, if infestation is severe.

Management: (a) Earth up and cover exposed portions of rhizomes; (b) dreach clumps with BHC (0.2%0.

11) Aphids (Pentalonia nigronervose F. caladii)

Aphids are important as they act as vectors of mosaic or 'katte' disease virus. Both nymphs and adults suck plant sap. They breed and colonise inside leaf sheaths of the old and damaged pseudostems. P. nigronervose f. caladii is found in cardamom and colocasia where as the form commonly found on banana is P. nigrenervosa f. typica and is not a virus vector.

Management: (a) Remove partly dried and decayed pseudostems harbouring colonies of aphids; (b) uproot and destroy other alternate hosts like colocasia in the plantation.

12) Minor Insect Pests

Beetle borers (Onthophagus coorgensis), grass hoppers, leaf hoppers, spittle bugs, cutworms, leaf beetles (Lems sp.) etc. also cause minor damages to cardamom in certain areas.

II. MITES (Tetranychus sp.)

Mites infestation is noticed both in nurseries (during November-April) and in main plantations. Mites penetrate plant tissues by their needle like mouth parts and suck exuding sap. The common symptoms are stippling, bronzing, defoliation, retardation of growth and reduction in size of leaves.

Management: Spray dicofol @ 1.5 ml/litre at monthly intervals. Application of wettable sulphur @ 1.5 kg/ha is also effective.

III. NEMATODES

Plant parasitic nematodes are potentially serious constraints to cardamom productivity. But the nature and magnitude of the problem go unnoticed due to lack of characteristic symptoms, their microscopic size and hidden habitat in the soil.

The perennial nature and other agronomic characteristics of cardamom are very congenial for nematodes. Although several groups of nematodes are associated with cardamom, the most important and widely distributed are the root-knot nematodes, Meloidogyne spp. The burrowing nematodes (Radopholus similis) and the lesion nematodes (Pratylenchus sp.) are usually found in mixed plantations with arecanut, coffee, pepper etc.

Root-knot nematodes are present both in nurseries and main fields of the entire cardamom growing tracts of South India. The predominant species is M. incognita. They feed on roots, make cardamom plants weak and vulnerable to other pests and diseases. In their presence, the nursery diseases like rhizome rot and damping off due to Rhizoctonia solani get aggravated.

Nature of damage

* Poor germination of seeds in primary nurseries
* Poor establishment after transplanting to secondary nurseries or main fields
* Yellowing and drying of leaf tips and margins
* Stunting and poor growth of the plants
* Shedding of immature capsules in main field
* Heavy galling (root-knots) and abnormal branching of roots, (Galling is prominent in seedlings while in mature plants the galls are small in size with abnormal branching of roots).

Nematode Management

* In nurseries: The most important step is the distribution and use of healthy, nematode free seedlings. For this, any one of the following measures may be adopted.

i. Fumigate primary and secondary nursery beds using Methyl Bromide (@ 500 g/10 sq.m.) or Ethylene-di-bromide (@ 20 l/ha) or Durofume (30 l/ha) under polythene cover for 2-3 days. This gives absolute control of nematodes, soil borne pests, weeds etc. (State warehousing corporation undertakes this work).

OR

Drench the nursery beds with 2% formalin.

ii. Treat the nursery plants with carbofuran @ 5 kg a.i/ha (i.e. one g a.i./row of 6 m length) after 10 days of germination and repeat after 3 months. In secondary nurseries, the plants may be treated along the rows with carbofuran @ 10 kg a.i./ha after transplanting and every three months afterwards.

iii. Do not use same site repeatedly for raising seedlings. If possible, rake soil of the site and expose to sunlight before taking up sowing. The roots should be pruned prior to distribution or transplanting.

• In the main field:

i. Treat the plants in the infested patches with carbofuran/phorate @ 5 g a.i./clump twice a year (April-May and September-October)

OR

Apply @ 500 g of neem oil cake/clump twice a year.

ii. Replant heavily infested areas with nematode-free planting materials after treating pits with nematicides

iii. Adopt regular phytosanitary measures like weeding, proper drainage, shade regulation etc.

IV. VERTEBRATE PESTS

Rodents like rats (Bandecota bengalensis) and squirrels (Funambulua spp.) cause severe damage to cardamom in certain areas by destroying capsules. Monkeys and wild boars also pose pestilence problems to cardamom in Malanad areas. Apart from these, some birds are also reported to feed on cardamom capsules.

Management: When damages due to these cause economic losses, measures like coating, trapping, etc. may be adopted. Debranching of trees in cardamom plantations is effective in minimising monkey menace. Selective shooting may have to be done where feeding pressure of wild boars is normally more.

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INSECT PESTS OF SPICES

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Infestation by insect pests is one of the reasons for the low productivity of spices in India. Though a number of insect pests have been recorded on black pepper, ginger, turmeric and tree spices, a few of them are important. Brief descriptions of these pests, their nature of damage, life history and control measures are discussed.

I. Black pepper

1. 'Pollu' beetle : Longitarsus nigripennis (Chrysomelidae : Coleoptera)

The 'pollu' beetle is the most serious pest of black pepper causing 30-40 per cent crop loss. The incidence of the pest is higher in plains and at altitudes below 300 m. The adult is a small shining beetle measuring 2.5 x 1.5 mm, the head and thorax being yellowish brown and the abdomen (elytra) black. The hind legs are stout and are adapted for jumping. Eggs hatch in 5-8 days into small grubs which are white with a black head and measure 1 mm length. Fully grown grubs are creamy-white and measure about 5 mm in length. The grub period lasts 20-32 days and fully grown grubs drop down to the soil and pupate in earthern cocoons. The pupal period lasts for 6-7 days.

The adult beetles feed and damage tender shoots, leaves and spikes. The females lay eggs on tender shoots, spikes and berries. Emerging grubs bore into and feed on internal tissues and the infested tender shoots and spikes turn black and decay. The entire internal content of tender berries are eaten and they become hollow. The infested berries turn yellow and finally black and crumble when pressed (the term 'pollu' denotes the

hollow nature of the infested berries in Malayalam). A single grub is capable of damaging 3-4 berries. The pest population is higher during September-October in the field. During the 'off season', the adults scrape and feed on undersides of mature leaves and are present in reduced numbers under shaded areas.

Spraying vines twice a year during June-July and September-October with endosulfan or quinalphos (0.05% each) is effective in controlling 'pollu' beetle. Undersides of leaves where adults are seen are to be sprayed thoroughly.

2. Top shoot borer : Cydia hemidoxa (Tortricidae : Lepidoptera)

The top shoot borer is a serious pest in younger plantations in all black pepper areas. Caterpillars of this moth bore into tender terminal shoots and feed on internal tissues resulting in blackening and decaying of affected shoots. When successive new shoots are attacked, growth of vine is affected. Pest infestation is higher during July to October when numerous succulent shoots are available on vines.

The adult is a tiny moth with a wing span of 10-15 mm with crimson and yellow forewings and grey hind wings.Female moths lay eggs on tender terminal shoots, larvae that hatch out scrape and feed on surface of shoots, bore into them. Fully grown caterpillars are greyish green and measure 12-15 mm in length;the larval and pupal periods last for 14 and 10 days, respectively.

Spraying of monocrotophos (0.05%) on tender terminal shoots is effective for control of top shoot borer. The spraying may have to be repeated to protect emerging new shoots.

3. Leaf gall thrips : Liothrips karnyi Bagnall (Phalaeothripidae : Thysanoptera)

Infestation by leaf gall thrips is more severe at higher altitudes and also in nurseries in plains. The feeding activity

of thrips on the leaves causes the leaf margins to curl downwards and inwards resulting in formation of marginal leaf galls. Later the infested leaves become crinkled and malformed. In severe cases of infestation, growth of younger vines is affected. Adults and juvenile stages live in colonies within the leaf galls induced by them.

Adults are black and measure 2.5-3.0 mm. The larvae and pupae are creamy white. Eggs are laid in small clusters within the leaf galls and they hatch in 6-8 days. The life cycle comprising larval and pupal stages is completed in 18-27 days.

Spraying of monocrotophos or dimethoate 0.05% at the time of emergence of new flushes in controls the pest infestation.

4. Scale insects : (Diaspididae : Hemiptera)

Among the various scale insects recorded on black pepper, the mussel scale Lepidosaphes piperis and coconut scale Aspidiotus destructor are important. Scale insects sometimes cause serious damage to black pepper vines at higher altitudes and also to older cuttings in nurseries. Females of mussel scales are elongated and dark brown and that of coconut scales circular and yellowish brown. Scales are sedentary, remaining permanently fixed to plant parts and appear as encrustations mainly on stems, leaves and berries. They feed on plant sap and cause yellowing and withering of infested portions; in severe cases of infestation the affected portions of vines dry up. The pest infestation is more severe during summer.

Scale insects can be controlled by spraying monocrotophos or dimethoate (0.1%); a second spray may be necessary to control infestation completely. It is important to undertake control measures during initial stage of infestation.

Leaf feeding caterpillars especially Synegia sp. damage tender leaves and spikes of younger vines in some areas. Spraying

of quinalphos 0.05% is effective in controlling the pest.

Plant sap feeders such as mealy bugs, white flies and aphids infest tender shoots. Spraying of monocrotophos (0.05%) may be undertaken if infestations are severe.

Though not a pest of black pepper, Ramphan sp. (Cerambycidae : Coleoptera) is a serious pest of Erythrina indica, a popular standard of black pepper, especially in new plantations established near forest areas. The grubs tunnel into the trunk and main root close to the ground level. The foliage of affected trees turn yellow and they topple down ultimately damaging vines. The grubs can be controlled by application of 20-30 g of phorate 10 G in the soil around the standard twice a year, during May-June and September-October.

II. Ginger and Turmeric

1. Shoot borer : Conogethes punctiferalis Guen. (Pyralidae : Lepidoptera)

The shoot borer is the most serious pest of ginger and turmeric. The larvae of the moth bore into pseudostems and feed on the internal tissues resulting in yellowing and drying of infested pseudostems. The presence of bore hole on the pseudostem through which frass is extruded and the withered central shoot is a characteristic symptom of pest infestation.

The adult is a medium sized moth with a wing span of about 20 mm; the wings are orangish yellow with minute black spots. The egg period lasts for 3-4 days. There are 5 larval instars lasting for 4-5 weeks. The pupal period lasts for 9-10 days. The pest population is higher in the field during August-October. The shoot borer is highly polyphagus and is recorded on 22 hosts.

Spraying malathion (0.1%) or monocrotophos (0.05%) at monthly intervals during July to October is effective in

controlling the pest infestation.

2. Rhizome scale : Aspidiella hartii (Coccidae : Hemiptera)

The rhizome scale infests rhizome of ginger and turmeric both in field and storage. Adult (female) scales are minute, circular and light brown to grey and appear as encrustations. They feed on sap and when the rhizomes are severely infested, they become shrivelled and dessicated affecting its germination. Soaking seed rhizomes in quinalphos (0.1%) before storing and sowing is effective in controlling pest infestation.

Larvae of leaf roller (Udaspes folus) cut and fold leaves of ginger and turmeric and feed from within. Adults are medium sized butterflies with brownish black wings with white spots; larvae are dark green. One spray with carbaryl (0.1%) or dimethoate (0.05%) may be undertaken in severe infestation.

Leaf thrips (Panchetothrips indicus) infest leaves of turmeric as a result of which they roll up. Later the leaves turn pale and dry up. The thrips can be controlled by spraying dimethoate (0.06%).

Lacewing bugs (Stephanitis typicus) occur in colonies and suck sap from leaves of turmeric. The infested leaves turn yellow and dry up. Spraying dimethoate (0.05%) is effective in controlling pest infestation.

Maggots of dipteran flies Mimegralla coeruleifrons and Eumerus pulcherrimus are often found associated with ginger rhizomes affected by soft rot disease. The maggots feed on the internal content of rhizomes. Though they were earlier reported as pests of ginger and turmeric, studies conducted at NRCS proved that they are not primary pests of these crops but feed only on diseased rhizomes.

III. CINNAMON

1. Cinnamon butterfly : Chilasa clytie (Papilionidae : Lepidoptera)

This is the most serious pest of the crop and is generally seen during the post monsoon period. The caterpillars of the butterfly feed on tender and slightly mature leaves. In severe cases of infestation, the entire plant is defoliated and only midribs of leaves with portions of veins are left behind. Adults are large sized butterflies. Males have blackish brown wings with white spots on outer margins; females have black wings with bluish white markings. Fully grown caterpillars are pale yellow with dark stripes on sides and measure about 2.5 cm in length.

Spraying with quinalphos (0.05%) effectively controls the pest infestation.

2. Leaf miner : Acrocercops sp. (Gracillaridae : Lepidoptera)

Infestation by the leaf miner is more common during monsoon season and generally nursery seedlings are seriously affected. The adult is a minute silvery grey moth. Caterpillars are pale grey initially and become pinkish red when fully grown measuring about 10 mm in length. They feed on the tissues between the upper and lower epidermis of tender leaves resulting in drying of damaged portions. Spraying with quinalphos 0.05% during emergence of new flushes is an effective prophylactic measure.

Apart from the fore-mentioned pests, many other leaf feeding caterpillars and beetles also occur sporadically on cinnamon. Application of quinalphos 0.05% would keep them under check.

IV. NUTMEG

1. Black scale : Saissetia nigra (Coccidae : Hemiptera)

Infestation by black scales occurs on tender shoots and leaves especially in the nursery. The scales are seen clustered together and are black, oval and dome shaped. They feed on the plant sap and severe infestations cause shoots to wither and plants present a sickly appearance.

2. Soft scale : Lecanium psidii (Coccidae : Hemiptera)

These are flat and oval shaped and occur clustered together on tender shoots and leaves. Infestation by these scales is more common in nursery seedlings. The infested plants wither and present a sickly appearance.

The fore-mentioned scale insects and other species that may also occur sporadically can be controlled by spraying monocrotophos 0.05%.

V. CLOVE

1. Stem borer : Sahyadrassus malabaricus (Hepialidae : Lepidoptera)

The stem borer generally infests the main stem of young trees at the basal region. The caterpillar girdles the stem and bores downward into it. The girdled portion and bore hole are covered with a mat-like frass material. The infested trees succumb to pest attack subsequently.

The pest infestation can be controlled in initial stages of attack by pouring a solution of quinalphos 0.1% into the bore hole after removing the frass and plugging the opening. Swabbing the main stem with BHC paste will prevent pest infestation.

2. Soft scale : Lecanium psidii (Coccidae : Hemiptera)

Infestation by soft scale occurs on tender shoots and leaves and nursery seedlings are more seriously affected.

Spraying with monocrotophos 0.05% effectively controls scale infestation.

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PROCESSING OF SPICES AND EVALUATION FOR QUALITY

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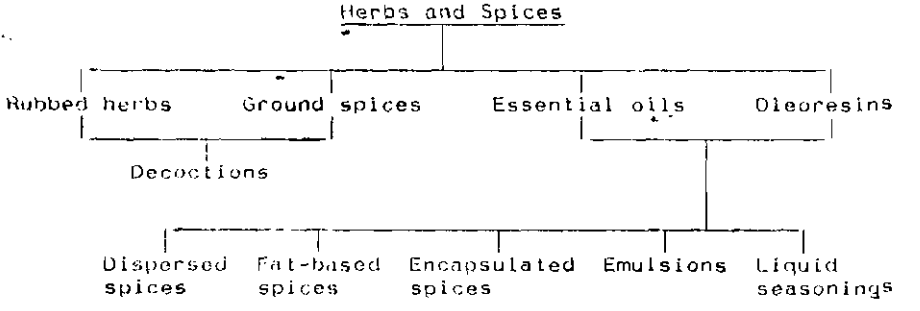
Spices occupy an important position in Indian culinery. It adds aroma and taste to preparations and mask the off flavour of stored and decomposing feeds. The nature of complex sensation of 'flavour' consists of simultaneous appreciation of the sense of taste, smell, sensation on tongue and linings of the mouth as well as less defined attributes such as heat and pungency.



These are some of the different ways of application of spice products in day to day use.

Spice products :

Ground spices occupy a major position in the world spice trade. Among spices, pepper is the most important followed by cardamom, cinnamon, ginger and turmeric.

Processed spices :

We know very well that natural spices cannot remain long with original aroma, flavour, taste etc. Then, what are the alternatives? There come processed spices like :

1. Spice essential oils
2. Spice oleoresins
3. Spice essences and emulsions
4. Spice decoctions
5. Other processed spice products

Spice essential oils :

Aroma and many of the flavouring characteristics are imparted by essential oils, extracted from the ground material by distillation. Use of essential oils overcomes the flavour variability as they are constant in flavour character. But the disadvantage is in certain spices especially pepper and ginger where the volatile oil gives only odour of the spice, the bite principles being non-volatile do not appear in the essential oil.

Spices oleoresins :

This represents almost the total flavour of spice. These are extremely concentrated products, obtained by solvent extraction and contain all the flavouring ingredients soluble in the particular solvent used.

As the name implies, oleoresin consists of a blend of essential oil and resinous matter, soluble in the particular solvent used. Selection of solvent for the extraction is very important. Generally, alcohol and food grade acetone are preferred.

Spice essences and emulsions :

Because of the high concentration of essential oils and oleoresins and their limited solubility, dilutions have an important role. This is achieved by use of solvents like glycerol, porpylene-glycol and iso-propyl alcohol.

Spices decoctions :

This is an extract prepared by boiling spices in presence of water or vinegar. The resultant liquor is called a decoction. Such decoctions have the advantage of being sterile and soluble, but as the water is not a good solvent for flavour constituents of spices, only a very small percentage of flavour is extracted.

Encapsulated spices :

Most of the essential oils are extremely volatile and are lost during storage of either ground spices or dispersed spices. This can be prevented by encapsulating spice oils and oleoresins by spray drying or some other method of obtaining an impermeable shell. This locks in the aromatics and thereby increases their shelf-life. The base normally used are gum acacia or gelatine.

Fat-based spices :

The standard spice extractives are presented in a fatty carrier which maybe either liquid (e.g. a vegetable oil) or solid (e.g. hydrogenated nut oil). Such products are designed for incorporation directly into any other fat component of a product.

Comparison of traditional and processed spices :

Ground spices

Disadvantages	Advantages
Variable flavour quality	Easy to handle and weigh accurately
Variable flavour strength	Slow flavour release in high temperature processing
Unhygenic	
Often contaminated by filth	
Flavour loss and degradation on storage	
Discolouration due to tannins	

Processed spices

Disadvantages	Advantages
Essential oils	
Flavour good but incomplete	Hygenic, being free from all bacteria
Flavour often unbalanced	Reasonable standard flavouring strength
No natural antioxidants present	Flavour quality consistent with the source of raw material
Rapidly sophisticated	Free from enzymes
Very concentrated - hence difficult to handle and weigh accurately	Free from tannins
Not readily dispersible, particularly in dry products	Stable on storage under good conditions
Oleoresins :	
Disadvantages	Advantages
Flavour good but as variable the raw material	Hygenic, being free from bacteria

Disadvantages	Advantages
Very concentrated - hence difficult to handle and weigh accurately	Can be standardised for flavouring strength
Range from liquids to	Contain natural antioxidents
	Free from enzymes
	Have long shelf-life under ideal conditions

Encapsulated spices :

Disadvantages	Advantages
Concentrated usually 10-fold so that weighing is difficult	Aromatics fully protected from volatile loss and degradation
	Long shelf-life under all conditions
	Readily incorporated into food mixes
	Free from objectionable odours
	Hygenically excellant
	Free from enzymes
	Low water content

I. Black pepper :

Pepper (Piper nigrum L.) is the most important exportable spice grown in India.

Important products from pepper -

1. Black pepper
2. White pepper
3. Pepper oil
4. Pepper oleoresin
5. Piperine
6. Dehydrated green pepper
7. Canned pepper

Black pepper :

Pepper, when matured (as indicated by one or two red berries in a vine) is harvested, despiked, cleaned off pin heads, and dried on a concrete floor, bamboo mat or high density polyethylene sheet under sun till it is crisp. The dried pepper should have a moisture of 8-10% (1/3 of green pepper is the normal dried black pepper).

To improve colour of dried product and to reduce the drying time, harvested green pepper is to be soaked in hot water for a minute and and then dried under sun. This process is called 'blanching'.

The dried black pepper should be free from cowdung and other extraneous matters (lot of export regulations are there on extraneous matters like bird excreta, cowdung etc.).

White pepper :

White pepper is prepared by removing the outer pericarp (skin) of the harvested berries by any one of the following techniques :

a) Water-steeping technique
   i) using ripe fresh berries
   ii) using dried berries
b) Steaming or water-boiling technique
c) Decortication technique

a) Water steeping technique :

i) Using fresh ripe berries : This is the traditional method in which the harvested ripe spikes or berries are packed in gunny bags or steeped as such in water tanks or running water for 7-10 days. The pin heads and light berries which float are separated. The remaining bigger berries are stirred 2-3 times

daily. Once the skin is softened they are rubbed by hand or trampled to remove the outer softened skin. The deskinned berries are sun-dried and sold as white pepper.

ii) Using dried berries : The dried black pepper berries are steeped in water for 10-15 days, whereafter they are removed, rubbed, washed thoroughly, steeped in bleaching solution, drained and sundried.

b) Steaming or boiling technique :

This process consists of steaming or boiling of fresh mature ripening berries for about 15 min. The boiled or softened berries are de-skinned, washed, bleached and sun dried.

The marketability of white pepper depends on white colour and boldness of berries.

c) Decorticatiion techniques :

White pepper is also prepared by decorticating black pepper in decorticating machines. Drawbacks in this process are (i) large breakage of berries, (ii) lack of uniformity in shape and surface.

Processed tender green pepper :

Semi-mature green pepper is used to make pickles. Green pepper berries are harvested and pickled fresh in 2% brine (common salt solution) or in 12-65% brine with vinegar etc.

Oehydrated green pepper :

CFTRI has developed steaming and rapid drying technique to dehydrate green pepper in order to preserve the green colour and stored for a year or more. This can be consumed by simple reconstitution (steeping in water) as in case of green peas.

Composition of pepper :

The bulk density of pepper ranged between 425 and 850 g/litre.

Starch accounts for 34% in black pepper and 56.5% in white pepper. The Kerala types like Kottanadan, Kumbhakodi and Kuthiravalli are high in piperine while the North Kanara types are low in piperine.

Pungent principles :

The alkaloid piperine is the major constituent responsible for the biting taste of black pepper. Other pungent alkaloids are chavicine, piperidine and piperettine. Piperine content in most pepper varieties ranged from 3-6%.

Oil of pepper :

The characteristic aroma of pepper is due to the volatile oil present in pericarp which ranges from 2-6%. The lower priced grades of pepper like damaged or broken fruits of pepper serve as an economic raw material for pepper oil.

Pepper oleoresin :

It is the concentrate of all the flavour components (aroma, taste, pungency and related sensory factors) and it truly recreates, when diluted, the sensory quality of the original natural material.

Uses :

Piperine has no marked physiological action. Pepper oil is a valuable adjunct in the flavouring of sausages, canned meats, soups, table sauces, perfumery and in medicine.

II. Cardamom :

The green colour of cardamom and the capsule size are the two important parameters to be observed in the post-harvest operations. The cardamom oil is commercially more important than the oleoresin as the former imparts full flavour of cardamom. The flavour of cardamom oil is determined by presence of various hydrocarbons, alcohols and esters in the oil. Among them, the major chemical constituents are 1,8-cineole and alpha-terpinyl acetate. A high terpinyl acetate and low cineole in the oil impart sweet flavour to the oil while a high cineole content impart more of a camphoraceous note to the oil which is not desirable. A washing in 2% sodium carbonate fixes the green colour of cardamom.

III. Ginger :

Ginger is exported mainly as dry ginger. Dry ginger is prepared after partially peeling off the outer skin of raw ginger and then sun drying for 10-12 days to a moisture level of 10%. Bleached dry ginger is prepared by dipping dry ginger in fresh slaked lime solution followed by sun-drying.

Dry ginger is used to make ginger oil, ginger oleoresin, ginger essence, soft drink or non-alcoholic beverages and vitaminised effervescent ginger powders are used in soft drinks.

Chemical composition :

Volatile oil	-	1.25-2.8%
Crude fibre	-	1.4-8%
Starch	-	40-50%
Acetone extract	-	3-8%

Products from ginger :

1. Ginger powder : It is a component in curry powder recipes. It is also used in preparing ginger beer, ginger wine etc.

2. Ginger oil : It gives the aroma of ginger. It is devoid of the pungent taste (bite) of the spice. Oil is light yellow in colour, chief constituent of ginger oil is sesquiterpene.

3. Ginger oleoresin : It is the total extract of ginger containing all flavouring principles of spice i.e., it contains both the essential oil which gives aroma of ginger and the resinous part which gives pungent taste. Oleoresin content varies 4-6%. Gingerol, the main pungent principle in the oleoresin is about 18-20%.

4. Crystallised ginger and candid ginger : Fresh ginger is used as the raw material. Low fibre ginger is used for these products.

IV. Turmeric :

Turmeric after harvest is washed well to remove adhering soil and cooked in boiling water for 1 hr under slightly alkaline conditions. The cooked material is dried under sun for 6-8 days. To smoothen its external surface and to improve colour, dried turmeric is subjected to polishing by sprinkling small quantities of turmeric powder.

The average composition of dried turmeric is moisture 5%, protein 8%, carbohydrates 63%, fibre 7%, volatile oil 3%, curcumin (total colouring matter) 3%, non-volatile matter 9%.

Colour of turmeric :

The yellow colour of turmeric is due to an orange yello pigment called curcumin. Turmeric contains 2.5-6% curcumin Pure curcumin is an orange-yellow crystalline powder insolubl in water, soluble in alcohol and in acetic acid.

Products from turmeric :

1. Turmeric oil : Turmeric contains 3-5% volatile oil The oil is pale yellow in colour. It contains 6% turmerone: 25% zingiberene.

2. Turmeric oleoresin : It is obtained by solvent extraction of ground spice. Acetone is a good solvent for oleoresin extraction. Curcumin, the main colouring matter, forms about one third of good quality oleoresin. For commercial use, oleoresin is mixed with a suitable vehicle or solubilizer such as propylene glycol, polysorbate or vegetable oil, so that handling is easier.

V. Tree spices :

Cinnamon :

The flavour components of commercial importance are bark, bark oil, bark oleoresin and leaf oils. Leaf oils contain 70% eugenol and 5% cinnamaldehyde and barkspoils contain 75% cinnamaldehyde and 6% eugenol. Bark oleoresin, bark oil and leaf oil are used as food adjuncts.

Clove :

Clove buds, stem and leaves on distillation yield 15%, 5% and 1.5% essential oil respectively. Clove bud oil is superior in quality compared to stem oil and leaf oil.

Nutmeg :

Both nut and mace are commercially very important. Chemical composition of nut and mace essential oil are almost the same. Main components of the oil as myristicin, elemicin and pinenes.

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PROPAGATION OF SPICES

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Non availability of quality planting material is an important constraint which limits productivity of spices. Clonal propagation techniques like cuttings, layering, grafting, and micropropagation methods are available in spice crops which could be adopted for commercial multiplication of high yielding lines.

BLACK PEPPER

Pepper is propagated conventionally through 2-3 noded cuttings of runner shoots. A rapid multiplication method with a multiplication rate of 1:40 is standardised at N.R.C.S. Pepper could also be grown as bushes by planting rooted cuttings of fruiting branches. These bush pepper have added advantages of flowering throughout the season and could be grown in pots without any support. Grafting of *piper nigrum* on to *Piper colubrinum*, which is resistant to *Phytophthora* foot rot has been standardized for both runner and lateral branches. *In vitro* methods for micropropagation of black pepper using short tip explants are available with a multiplication rate of 1:8.

CARDAMOM

Cardamom is propagated from seedlings or vegatatively by suckers. Being a cross pollinated crop, propagation through the latter method is ideal gor generating true to types of high yielding clumps. A rapid propagation technique for production of suckers through trench method is developed at N.R.C.S. The micropropagation technique is being made use of for multiplying high yielding varieties of cardamom and for supplying disease free planting materials.

GINGER

Clonal multiplication is the only way to multiply ginger since ginger does not set seeds in natural condition. Ginger is propagated traditionally through 3-5 cm long rhizomes weighing 20-30 g. Ginger being a vegetatively propagated crop responds to *in vitro* propagation techniques. Protocols for production of pathogen free planting material through tissue culture are standardised.

TURMERIC

Turmeric is commercially propagated through finger or rhizomes with one or 2 buds. *In vitro* techniques are available at present which could be used for rapid multiplication of the crop.

NUTMEG

Identification of the sex before the tree flowers is difficult when propagated throug seeds and hence the need for vegetative propagation.

Nutmeg can be propagated through cutting, layering and budding. However the percentage success is very low for commercial multiplication. Epicotyl grafting of nutmeg standardised at N.R.C.S is used for large scale multiplication of female plants. Though different wild root stocks like *Myristica malabarica* and *Myristica beddomii* were used for grafting, the percentage success was very low. Grafting on *M. fragrans* rot stock was the best. A success of 90-95% was obtained when grafting was done on 20-30 days old root stock.

CINNAMON

Cinnamon is the dried inner bark of *Cinnamomum verum* prest. A lot of variation exists in the seedling progenies of cinnamon and these variations are mostly reflected on the yield and quality of cinnamon. Clonal propagation of this spice is

essential to preserve the characters of the mother plant since it is a cross pollinated crop.

Cinnamon can be propagated vegetatively through cuttings and IBA and IAA (2000 ppm) hasten the process of rooting in this crops. 70-80% of the cuttings and layering could be rooted through use of hormones.

CLOVE

Clove is propagated through seeds for its commercial multiplication. However, vegetative propagation techniques like approach grafting is available for its multiplication. Approach grafting can be done round the year, but the best period for grafting is September-November. This technique has an added advantage of reducing the pre bearing period.

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CULTIVATION OF SEED SPICES IN INDIA

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India is the world's largest producer, consumer and exporter of seed spices. The most important seed spices grown under different agro-climatic zones are coriander, cumin, fenugreek and fennel. These spices are not only important as items of home consumption but also earn foreign exchange. The area production and productivity of important seed spices and the states in which they are grown are given below:

Table : Area and Production of important seed spices grown in India

Seed spices	Area (ha)	Production (Qt.)	Productivity (kg/ha)	States growing
Coriander	334910	211500	632	Andhra Pradesh Rajasthan Madhya Pradesh Tamil Nadu Karnataka
Cumin	131730	71780	545	Gujarat Rajasthan
Fenugreek	34250	34040	1117	Rajasthan Gujarat Uttar Pradesh
Fennel	15960	17830	994	Gujarat Rajasthan Uttar Pradesh

The causes for low productivity of these seed spices are due to cultivation in marginal lands with poor fertility, lack of improved varieties and poor adoption of package of practices including disease and pest management. Slow as well as poor germination with high incidence of diseases like wilt, powdery mildew, and lack of response to fertilizer are some of the important factors responsible for low productivity.

Coriander (*Coriandrum sativum*)

Coriander has its origin in Mediteranean region. It is the condiment in use from earliest time of mankind. The green leaves and stems of young plants are in use in every day cookery and so also the seeds. Cordials and toilets are prepared from it in foreign countries. The Moroccan and Russian varieties contain high volatile oil up to 1.0% in seeds and hence preferred for distilling oil whereas Indian variety has only 0.2% oil. The essence of coriander is used for flavouring biscuits, cakes, jellies, etc. It is a carminative, refrigerant, diuretic, tonic and aphrodisiac. Seed analysis - 11.2% water, 14.1% albuminoids, 16.1% fat, 21.5% carbohydrate, 32.6% fibre and 4.4% ash.

Adaptation and soil : It is grown as dry crop in black cotton soils and heavy clayey soils and also as an irrigated crop in red loamy soils. It is a typically black cotton soil crop.

Varieties : The important varieties under cultivation and their characteristic features are as follows:

Coriander varieties

Variety	Pedigree	Yield (kg/ha)	Crop duration (days)	Grain size	Essential oil (%)
Co-2	Reselection	520	90-110	Medium	0.40
Guj.Cori-2	Reselection	1450	110	Bold	0.40
RCr-41	Recurrent selection	1200	140	Small	0.25
Sadhana	Mass selection	1025	100	Medium	0.20
Swathi	Mass selection	885	83	Medium	0.30
Co-3	Pure line selection	650	86-104	Medium	0.40
CS-287	Reselection	600	78-97	Medium	0.38
Sindhu	Mass selection	1050	102	Medium	0.40

Distribution : The crop is grown in India, Russia, Morocco, Asia minor, Central Europe.

Mixed cropping and rotation : For seed purposes it is grown in field scale and for green leaves as port-herb in vegetable garden. It is grown as a pure crop and as a mixed crop as well. As a pure crop in garden land and as a mixed crop with cotton and black gram in dry lands. In Southern districts of Tamil Nadu coriander-cotton mixed cropping is very common. In a mixed cropping experiment in Tamil Nadu

coriander yielded 200 kg per hectare with only slight decrease of cotton yield. Rotation in early rainfall regions in dry land is gingelly - (early crop) followed by coriander as late crop or coriander as early crop and Bengal gram in late season. In Mysore coriander is mixed with black gram or grown as a pure crop.

Cultivation details : The field is ploughed 4 or 5 times and the "mericarps" obtained by splitting the seeds into two by pressing under feet are sown at 10 to 15 kg per hectare and covered by country plough. In North India it is sown in winter season and in Tamil Nadu during North-East monsoon period, in Mysore and parts of Tamil Nadu, it is raised during May to August and October to January. In Punjab the seed rate goes up to 25 kg. per hectare. One or two hoeing and weeding are given. The crop matures in 3 to 3½ months.

In gardenland, manuring with 10 to 15 cartloads of FYM per acre is done before last ploughing. The crop is grown in beds and once in a week irrigation is given. NPK fertilizers recommended per ha is 30-40-20 in soils rich in potash status.

Harvesting is done (when seeds mature) by pulling out plants and they are dried for three or four days as thick layers, threshed under feet of cattle. For small quantity, beating with stick is common.

In Coimbatore, the pulled out plants are heaped with shoots inside and roots outside and after a fortnight, threshing is done. It is believed to enhance the flavour of seeds.

Yield : In dry land, 300 to 450 kg per hectare is obtained and in irrigated lands the yield varies from 650 to 1000 kg seeds.

Marketing : A small quantity is exported to Ceylon where it is not able to compete with Russian and Moroccan varieties which contain high flavour and more purity.

Fenugreek (Trigonella foenum)

Introduction : The fenugreek seed is extensively used as condiment in Indian cookery. The green plants are also used as a vegetable, gathered when they are young and tender and long before they begin to flower.

Distribution : Fenugreek is a native of Southern Europe and Asia and has been grown throughout India and parts of North Africa as a flavouring material. Considerable quantities are exported from India, Morocco, but the plant is mainly used locally for a variety of purposes. It is grown in Egypt and Sudan purely under irrigatioin. Important Fenugreek growing countries are India and North Africa. Punjab is the chief Fenugreek producing state.

Soils : The Fenugreek is suited to the tracts of moderate or low rainfall and cannot be cultivated in high rainfall regions. Crop is grown on well drained loamy soils with irrigation. It is grown in heavy black cotton soils as a rainfed crop in the early season. Crop can be grown in both the seasons - early and late. It can be grown all through the year as a pot herb for the kitchen.

Rotation : Fenugreek is grown as an early season crop in drylands and it is possible to take another crop in the same field during the late monsoon. It is grown as a pure crop of mixed with coriander, green gram and gingelli. Fenugreek is sown in alternate strips when raised mixed with other crops. It is rotated with wheat, bengal gram or late season maize. Grown as an irrigated crop, it is generally followed by a grain crop like ragi or maize or other garden land crops.

Fenugreek varieties

Variety	Co-1	RMt-1	Lam Sel.1
Pedegree	Reselection	Pure line selection	Selection
Yield (Kg/ha)	680	1560	740
Duration(days)	95	145	90
No. of pods/ plant	31	48	21
No of seeds/ pod	17.1	15.6	15.0
Diosgenin(%)	-	0.2	-
Seed protein(%)	21.7	21.0	53.0

Cultivation : The field for sowing fenugreek is well prepared by working the heavy bladed harrows with the help of early rains. Seeds are sown by seed drills, the lines being nine inches apart. Seeds are covered by working a light bladed harrow. The seed rate for a pure crop is 20 per hectare. The seeds sprout quickly and visible above around in three days.

For irrigated crop, the field is well prepared and manured heavily. Bed and channels are formed after covering the manure. Seeds are sown broadcast at the rate of 10 to 12 kg of seeds per acre and stirred in well. The crop is irrigated regularly. A good portion of plants is removed for green vegetable purposes. An interculturing is given to the crop two weeks after sowing. The fenugreek crop is raised for fodder purposes in North India. The crop is harvested at the time of seed setting for this purpose. Crop takes only about 2½ to 3 months to mature. The plants are pulled out by the roots and brought over to the threshing floor where they are dried in the sun. Plants are beaten with sticks to free the seeds from pods. Produce is winnowed and cleaned. Further drying is given to seeds before their storage or sale.

Crop yields about 800 kg of seeds per ha when grown as an irrigated crop. Yields very depending upon the method of cultivation.

Uses : Seeds are highly aromatic and contain about 23% of protein, 9% of oil, 10% carbohydrate and considerable amount of fibre and resinous material. The flavour of the seeds is due to the presence of an essential oil containing coumarin. Seeds are used as a constituent of curry powders and as a condiment, and find many uses in medicine. An yellow due is prepared from the seed. It is also a good cattle feed. Seeds contain two alkaloids namely choline and trigonelline. It is also used in veterinary medicine. It is grown for fodder purpose in Punjab.

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TRENDS IN PRODUCTION, CULTIVATION, PROCESSING AND STORAGE OF CHILLIES, HERBAL AND MISCELLANEOUS SPICES

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India has a wealth of many spices. Among these, 30 crops are of special importance (Table 1).

Table 1. List of seed and herbal spices

Common name	Botanical name	Family	Parts used as spice
Chilli	*Capsicum annuum*	Solanaceae	Dried fruit
Aniseed (Anise)	*Pimpinella anisum*	Apiaceae	Dried seed
Basil (Sweet basil)	*Ocimum basilicum*	Lamiaceae	Leaves
Bay (Laurel)	*Laurus nobilis*	Lauraceae	Leaves
Caraway	*Carum carvi*	Apiaceae	Dried seed
Celery	*Apium graveolens*	Apiaceae	Dried seed
Chervil	*Anthriscus cerefolium*	Apiaceae	Leaves
Chive	*Allium schoenoprasum*	Alliaceae	Leaves
Coriander	*Coriandrum sativum*	Apiaceae	Dried seed
Cumin	*Cuminum cyminum*	Apiaceae	Dried seed
Dill	*Anethum graveolens*	Apiaceae	Dried seed
Fennel	*Foeniculum vulgare*	Apiaceae	Dried seed
Fenugreek	*Trigonella foenumgraecum*	Fabaceae	Dried seed
Garlic	*Allium sativum*	Alliaceae	Cloves
Horseradish	*Armoracia rusticana*	Brassicaceae	Roots
Marjoram	*Marjorana hortensis*	Lamiaceae	Cut plant
Mint	*Mentha* species	Lamiaceae	Cut plant
Mustard	*Brassica* species	Brassicaceae	Seed
Onion	*Allium cepa*	Alliaceae	Bulb

Origano	Origanum vulgare	Lamiaceae	Dried leaves, stalks and floral parts
Parsley	Petroselinum crispum	Apiaceae	Leaves
Poppyseed	Papaver somniferum	Papaveraceae	Seed
Rosemary	Rosemarinus officinalis	Lamiaceae	Entire plant
Saffron	Crocus sativus	Iridaceae	Stigmas
Sage	Salvia officinalis	Lamiaceae	Leaves
Savory	Satureja species	Lamiaceae	Flowering tops
Sesame seed	Sesamum indicum	Pedalliceae	Seed
Staranise-tree	Illicium verum	Illiciaceae	Dried seed/fruit
Terragon	Artemisia dracumculus	Asteraceae	Flowering tops and leaves
Thyme	Thymus vulgaris	Lamiaceae	Leaves & flowering tops

It includes major crops like chilli, onion and garlic. Onion and garlic are now crops of commerce and are dealt extensively by organisations like Associated Agricultural Development Foundation (National Horticultural Research and Development Foundation). The ecological requirements for the 30 listed species are as varied as coriander in arid areas to celery in temperate cool climate. The edible part pertains to dried seed in fennel, dill, mustard and sesamum to dried leaves in origano and parsley. Botanically, the 30 species belong to families from Alliaceae as in onion to Apiaceae as in coriander, cumin and dill.

The seasonal spices are classified into five groups - pungent spices, aromatic fruits, umbelliferous fruits, phenolics spices and coloured spices (Table 2).

Table 2. General classification of seasonal spices

1.	Pungent spices :
	Chilli, Mustard and Horse radish
2.	Aromatic fruits/seeds :
	Fenugreek
3.	Umbelliferous fruits/seeds :
	Anise, Fennel, Caraway, Dill, Celery, Parsley, Cumin, Coriander
4.	Phenolics species containing eugenol
	Bay leaves
5.	Coloured spices
	Paprika, Saffron

Majority of the spices are umbelliferous fruits. The seasonal spices further vary in their nutritive composition (Table 3).

Table 3. Nutritive composition of seasonal spices/100 g of edible portion

Spices	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Vitamin A (IU)
Chilli	0.59	1.66	14.2	63.7	6165
Basil	0.15	0.32	6.9	61.3	290
Bay	0.10	0.42	2.0	46.6	545
Caraway	0.38	0.38	8.1	12.8	580
Celery	0.41	0.49	4.4	17.2	650
Coriander	0.26	0.23	3.2	12.0	175
Cumin	0.73	0.38	2.5	17.2	175
Dill	0.42	0.28	2.8	12.0	175
Fennel seed	0.41	0.36	6.0	12.0	1040
Garlic powder	0.68	0.08	0.7	12.0	175
Marjoram	0.29	0.32	4.1	51.5	550
Mustard	0.65	0.45	8.5	22.1	195

Onion	0.42	0.06	0.6	14.7	175
Origanum	0.34	0.04	6.2	12.0	1010
Parsley	0.17	1.23	7.9	392.0	1090
Poppy seed	0.69	0.18	0.9	12.0	175
Rosemary leaves	0.51	0.04	1.0	61.3	175
[illegible]	0.75	0.14	5.7	11.8	2495
Sesamum seed	0.80	0.11	5.7	12.0	34%
Tarragon	0.25	1.34	8.9	12.0	175
Thyme	0.51	0.40	4.9	12.0	175

Source : Research 900 Laboratories, St. Louis, M.O.

Sesamum seed has thiamine content as high as 0.80 mg/100 g. Chilli has a higher content of riboflavin (1.66 mg/100 g) and niacin (14.2 mg/100 g) and vitamin A (6165 IU/100 g). Parsley has the highest content of ascorbic acid (392 mg/100 g).

Chilli being a major seasonal spice, demands a better exposition. In India, Chilli is grown in almost all States (Table 4).

Table 4. Area, production and average yield/ha of chillis in India (1991-92)

State	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
Andhra Pradesh	217.9	260.4	1195
Assam	12.5	7.6	608
Bihar	5.9	5.1	864
Gujarat	13.5	15.9	1178
Haryana	3.7	4.2	1135
Himachal Pradesh	0.5	0.2	400
Jammu & Kashmir	0.8	0.4	500
Karnataka	122.7	35.1	286
Kerala	0.6	0.6	1000
Madhya Pradesh	43.9	9.7	221
Maharashtra	129.4	67.5	522
Manipur	4.7	2.8	596

Meghalaya	1.8	1.0	555
Nagaland	0.1	0.3	--
Orissa	90.4	75.6	836
Punjab	2.7	4.2	1555
Rajasthan	39.5	34.9	883
Tamil Nadu	56.0	32.0	571
Tripura	1.5	0.7	467
Uttar Pradesh	19.3	15.2	788
West Bengal	50.5	39.9	790
Arunachal Pradesh	1.1	1.1	--
Delhi	Negligible	Negligible	--
Mizoram	2.9	2.3	793
Pondicherry	Negligible	0.1	--
All India	822.4	616.5	750

Andhra Pradesh has the highest area and production followed by Maharashtra and Karnataka. Productivity of chilli is the highest in Punjab (1.55 t/ha) followed by Andhra Pradesh (1.20 t/ha). Productivity is the lowest in Madhya Pradesh (0.22 t/ha). India is a major exporter of chillies. During 1992-93, it exported chillies worth Rs. 678.6 million (Table 5).

Table 5. Export of seasonal spices from India

Commodities	1991-92		1992-93	
	Quantity (tonnes)	Value (Lakh Rs.)	Quantity (tonnes)	Value (Lakh Rs.)
Chilli	33398	9790.6	16850	6786.6
Coriander	9228	1190.4	13550	1991.5
Cumin	1460	589.5	2080	1176.9
Celery	2782	463.7	2750	418.3
Fennel	1663	362.7	2650	635.8
Fenugreek	4941	424.1	4850	521.2
Garlic	9894	763.3	7700	716.9

Source : Spices Board, 1993; 20th Meeting Agenda.

A large number of production constraints limit chilli production in the country (Table 6).

1.	Chillies :	
	a)	Incidence of leaf curl and bacterial wilt
	b)	Absence of varieties high in capsaicin, oleoresin and capsanthin
	c)	Absence of hybrid technology
2.	Coriander, cumin, fennel and fenugreek :	
	a)	Slow seed germination
	b)	Poor establishment
	c)	Lack of adequate and consistent response to application of NPK, high incidence of diseases like cumin wilt, cumin blight and powdery mildews
	d)	Lack of frost resistant varieties in coriander and fenugreek
	e)	Lack of hybrid varieties in coriander, cumin, fenugreek and fennel

Among the production constraints, incidence of leaf curl and bacterial wilt are major problems. Chilli hybrids which are early, high yielding and disease resistant are yet to take root in India. A large number of complex diseases limit chilli production (Table 7).

Table 7. Complex diseases in chilli

Complex diseases	Causitive organisms	Resistant varieties, if any
Pepper virus complex	Two strains of TEV, a common strain of potato virus Y and pepper virus	--
Leaf curl complex	Tobacco leaf mottle curl virus, pepper mottle virus, mites, thrips and aphids	Myliddy 1, Myliddy 2, Tennelveli B_3 & Tennelveli B_{16}

Rapid decline	Fusarium oxysporum, Fusarium vasinfectum, Phytophthora capsici, Fusarium equiseti and Rhizoctonia solani	--
Mosaic complex	Potato virus Y, Potato virus X, TMV, CMV, Chilli Mosaic virus, TEV, Alpha alpha mosaic virus	A-127, G-1, IC 342S, Puri Red, Puri Orange & Kondivenum
Moria disease	Lack of crop rotation, accumulation of organic matter, high soil temperature and several fungi	-

These include pepper virus complex, leaf curl complex, rapid decline, mosaic complex and moria disease. Varieties like Myliddy 1 and Myliddy 2 are identified as resistant to leaf curl complex. The economic loss due to a few major diseases have been worked out (Table 8).

Table 8. Economic loss due to disease incidence in chilli

Diseases	Economic loss	Reported by
Leaf curl	100%	Anon (1976)
Bacterial soft rot	9%	Cepeda and Butter field (1974)
Mosaic by TEV	6.53%	Villalon (1975)
Fruit rot by Alternaria	50%	Caurter et al. (1965)

Leaf curl causes complete economic loss. Research efforts are underway to evolve high yielding varieties of chilli (Table 9).

Table 9. Chilli varieties, their sources, suitable geographical zones and yield evaluated under A.I.C.V.I.P.

Chilli varieties	Sources	Suitable zones	Performance (Q/ha)	Remarks
Andhra Jyothi	Lam	1,4,5,6.7.8	4-6	Stout fruit, high seeded, pungent, glossy red pericarp
Bhagyalakshmi	Lam	1	1.6-4.5(dry)	Fruit length 8.2 cm, width 0.7 cm
K_2	Kovilpatti	1,5,6	3-10(dry)	Fruit pendent, length 6.1 cm, girth 4 cm, bright scarlet red fruits, tolerant to thrips
J 218	Jabalpur	6	6.5(dry)	Plant dwarf, fruits long (10-11 cm) and thin, 3 cm girth
Musalwadi	Rahuri	1,3	1.93(dry)	Average plant height 52.83 cm, fruit length 6.83 cm, width 0.95 cm
X 235	Lam	6,7	3.7(dry)	Highly pungent, suitable for pickling and export

Till date, six varieties were released in addition to varieties like Pusa Jwala, NP46 A, Pant C1 and Pant C2. The findings under AfCVIP have come up with a set of agronomic practices to increase productivity in chilli (Table 10).

Table 10. Agronomic practices recommended for chilli

Variety	Centre	Type of cultural practices	Recommendations
Pant C1	Faizabad	Fertilizer	120-150 kg N/ha split into 60 kg basal and rest in 2-3 equal quantities
Local	Coimbatore	Nitrogen	100 kg N/ha split into 50 kg basal, 50 kg top dressing 30 DAP
Pant C1	Faizabad	Fertilizer	Application of 90 kg N/ha along with basal doses of 60 kg P_2O_5 and 40 kg K_2O/ha

This includes fertilizer application in chilli. Research results are also available for disease control measures in chilli (Table 11).

Table 11. Disease control measures in chilli

Variety	Disease	Control measures
Sindhur	Fruit rot	Dithane M 45 (0.25%) 2-3 sprays during fruiting stage
Pusa Jwala	Dieback and fruit rot	Seed treatment with ceresan wet (0.1%) + four sprays of Bavistin (0.05%)
Pusa Jwala	Fruit rot, Powdery mildew and thrips	Three sprays at 15 days interval with combination of Dithane M 45, Karathane (0.1%) and Metasystox (0.1%)

Local	Disease and pest complex (fruit rot, dieback, thrips, mites and pod borers)	Preventive spray schedule of Dithane M 45 (0.3%) sprayed alternatively with monocrotophos (Nuvacron 40 EC) (0.5 kg a.i./ha)
Pusa Jwala	Bacterial leaf spot and fruit rot	Preventive spray of Agrimycine (100 ppm) + Blitox (0.3%) during rainy season. 3 sprays in October + Dithane M 45 (0.25%) at 15 days interval from last week of November to January

Now control measures are available against dieback, fruit rot, powdery mildew and bacterial leaf spot. Control measures have also been worked out against major pests of chilli-like podborer and pest complex (Table 12).

Table 12. Pest control measures in chilli

Variety	Pest	Control
G 4	Pod borer	Cypermethrin (0.1 kg a.i./ha) 3 sprays fortnightly
G 4	Pest complex (Pod borer, mites, thrips and aphids	Chlorophyriphos (0.5 kg a.i./ha) sprayed at 15 days interval

Recently, a good number of varieties high yielding and suitable for processing have been evaluated under AICVIP (Table 13).

Table 13. Recent chilli varieties under evaluation

Varieties	:	Source
TC 2	:	BARC
KCS-1	:	Kalyanpur
Phule-G	:	Rahuri
DPLC	:	Dapoli
LAL-248	:	Lam
BL-21-2	:	Bhubaneswar
TCA-283	:	Jabalpur
CA-219	:	KAU
X-235 (Check)	:	Lam
T-218 (Check)	:	Jabalpur

Attempts are also made to evaluate chilli varieties for contents of oleoresin, total extractable colour and capsaicin. The oleoresin content varied from 9.65% in TC 1 to 15.4% in LCA-206 (Table 14).

Table 14. Quality parameters of a few selected chilli varieties

Varieties	Vitamin-C (mg/100 g)	Oleoresin (%)	Total extractable colour(ASTA) units)	Capsaicin (%)	Crude fibre (%)
LCA-235	145.20	13.40	106.06	0.68	22.70
KCS-1	145.20	10.00	112.12	0.49	24.85
LCA-206	145.20	15.40	127.27	0.42	28.93
TC-1	145.20	9.69	96.96	0.48	27.86
Sel-1	220.00	13.90	119.09	0.44	31.97
KAU Cluster	220.00	10.00	136.36	0.52	31.01
Jawahar-218	176.00	9.70	-	0.72	26.00
LCA-248	176.00	11.00	119.69	0.48	27.00
Mussalwadi	176.00	9.70	106.06	0.56	25.10
TC-2	176.00	13.30	121.21	0.58	27.86

CA-586	132.00	12.40	118.18	0.64	26.50
Local	202.40	14.70	90.00	0.70	2.10
High	-	-	101-150	1.00-1.50	-
Medium	-	-	70-100	0.25-0.75	-
Lower	-	-	70	0.11-0.25	-

Capsicum annuum and Capsicum chinenese are recently analysed to contain high values of capsaicin (0.92%), oleoresin (34.40%) and colour (58.62 ASTA units).

Marketing in chilli remains a major constraint. The major marketing centres are located in Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu (Table 15).

Table 15. Major chilli marketing centres in India

State	Centres
Maharashtra	Nasik, Ahmed Nagar, Sholapur, Aurangabad, Nanded, Amaravathi, Lasalgaon
Andhra Pradesh	Guntur, Warangal, Hyderabad, Cuddapah, Vijayawada, Rajamundri, Nellore
Karnataka	Dharwad, Mysore, Hassan, Bangalore, Bellary, Ranibennur, Hubli, Byadgi
Tamil Nadu	Pollachi, Ramanad, Madurai, Trichi, Thani, Dindigul, Virudu Nagar, Sattur.

The marketing channels for chillies are of nine types. The co-operative type of marketing is yet to take a start in chilli (Table 16).

Table 16. Marketing channels for chillies and seed spices

1. Producer farmer to consumer
2. Producer farmer to retailer to consumer
3. Producer farmer to wholesaler to consumer
4. Producer farmer to wholesaler to retailer to consumer
5. Producer farmer to commission agent to wholesaler to consumer
6. Producer farmer to commission agent to wholesaler to retailer to consumer
7. Producer farmer to commission agent to wholesaler to processing factory to spice trader to selling agents (within country and abroad) to consumer
8. Producer farmer to commission agent to consumer enterprises (Hotels etc.)
9. Producer farmer to processor to commission agent (abroad) to retailer to consumer

The commission agents still take a major share of consumer's price. Cost of cultivation in chilli is going up due to high cost of labour and plant protection chemicals. The hired human labour consumes 18-22% of the total cost of cultivation in Andhra Pradesh.

Table 17. Breakup of total production costs in chilli (Rs.)

Item	Small farm	Large farm	Average
Hired human labour	2505 (18.85)	3052 (22.18)	2779 (20.54)
Bullock labour	685 (5.15)	507 (3.48)	596 (4.41)
Machine labour	82 (0.61)	307 (2.23)	195 (1.44)
Seeds	363 (2.73)	370 (2.69)	367 (0.271)

Manures and fertilisers	1825 (13.74)	2258 (16.41)	2042 (15.09)
P.P. chemicals	2470 (18.58)	2815 (20.15)	2643 (19.54)
Irrigation	125 (0.94)	125 (0.91)	125 (0.92)
Depreciation	216 (1.62)	182 (1.32)	199 (1.47)
Interest on working capital	431 (3.24)	499 (3.63)	465 (3.44)
Cost A_1	8702	11115	9411
interest on fixed capital	151 (1.13)	126 (0.91)	139 (1.03)
Rental value of owned land	2770 (20.84)	2747 (19.96)	2759 (20.39)
Cost B	11623	12988	12309
Family labour	1665 (12.53)	774 (5.63)	1219 (9.02)
Cost C	13287	13762	13528

Source : Eshwara Prasad, Y., Reghuram, P., Satyanarayana, G. and Lekshmana Rao, M. 1980. Economic analysis of chilli farming in Guntur district. Spice India 1 : 27-30.

The spices other than chilli, onion and garlic have not received the desired research attention. Yield gaps in a few of the seasonal spices are astonishing due to varied reasons. It is 5.15 times in cumin (Table 18).

Table 18. Yield gaps in some of the seasonal spices

Spices	National average (kg/ha)	Highest recorded yield (kg/ha)	Yield gaps
Coriander	618	1068	1.72
Cumin	283	1457	5.15
Fennel	550	1060	1.92

Source : Nair, M.K. 1989. Indian spices forging ahead for overall excellence. Spice Fair 1989. Spices Board, Cochin. pp.228-233.

India has immense potentiality to grow these spices. Our proposed target for miscellaneous spices is 4000 MT. The world demand is also going up for chillies and seed spices (Table 19).

Table 19. India's proposed target of chillies and seasonal spices export by 2000 AD

Commodities	Projected world demand	India's proposed target
Chillies	37,000 MT	15,000 MT
Spice seeds	90,000 MT	30,000 MT
Miscellaneous spices	9,600 MT	4,000 MT

Coriander occupies an area of 3.20 lakh ha during 1991-92 with a production of 1.48 lakh tonnes (Table 20).

Table 20. Area and production of seasonal spices in India

Commodities	1991-92	
	Area	Production
Chilli	822.4	616.5
Coriander	319.4	147.9
Garlic	92.8	364.0

Area in '000 ha and production in '000 M tonnes.

The potentials for export of the minor spices are very high. There are three main regions for export (Table 21).

Table 21. Main international markets for chillies and annual spices

1. WANA region (West Asia and North Africa)
2. Commonwealth of Russia and other E.E. countries
3. Western Europe, USA, Canada, Japan and Australia

The WANA region is a very potential area. The Government has taken a good number of measures to improve quality of minor spices exported.

A large number of organisations work on chillies and other minor seasonal spices in India (Table 22).

Table 22. Major organisations working on chilli and annual spices

	Organisations	Mandate crops
1.	Directorate of Vegetable Research (ICAR), Varanasi	Vegetables including chilli
2.	Central Institute of Medicinal and Aromatic Plants 9cimap), Lucknow	Medicinal and aromatic plants
3.	All India Coordinated Research Project on Medicinal and Aromatic Plants, NBPGR, IARI Campus, New Delhi	Medicinal and aromatic plants
4.	National Botanical Research Institute, Lucknow	Medicinal and aromatic plants
5.	National Research Centre for Spices, Calicut	Spices
6.	All India Coordinated Research Project on Spices, Calicut	Spices

7.	Central Arid Zone Research Institute, Jodhpur, Rajasthan	Coriander, Cumin, Fennel, Fenugreek etc.
8.	Indian Cardamom Research Institute, Myladumpara, Idukki, Kerala	Herbal spices, Cardamom

Lorenz and Maynard (1980) compiled information on various climatic, soil and water requirements of a few annual spices grown mainly as vegetable. Parsley requires an optimum range of 10-29°C for seed germination (Table 23).

Table 23. Soil temperature conditions for seed germination

Annual Spices	Minimum (°C)	Optimum range (°C)	Optimum (°C)	Maximum (°C)
Celery	4.4	15-21	21	29
Onion	1.7	10-35	24	35
Parsley	4.4	10-29	24	32
Chilli	15.5	18-35	29	35

Average monthly temperature for best growth and quality of a few annual spices are also reported (Table 24).

Table 24. Approximate monthly temperature for best growth and quality of a few annual spices grown as vegetables

Temperature (°C)			Annual Spices
Optimum	Minimum	Maximum	
13-24	7.2	29	Chive, Garlic, Onion
15-18	4.4	24	Horse radish
15-18	7.2	24	Celery, Florence Fennel, Parsley
21-29	18.0	35	Chilli

The optimum temperature for crops like horse radish, celery, florence fennel and parsley is 15-18°C. Information is also available on the temperature and time required for growing plants for field transplanting in a few annual spices (Table 25).

Table 25. Temperature and days required for growing plants for field transplanting in a few annual spices

Annual spices	Day temperature (°C)	Night temperature (°C)	Time in weeks
Celery	18-24	15-18	10-12
Onion	15-18	13-15	10-12
Chilli	18-24	15-18	6-8

The rooting patterns of a few crops have also been studied. Celery, garlic, onion and parsley are shallow rooted (Table 26).

Table 26. Characteristic rooting depths of a few annual spices

Shallow (45-60 cm)	Moderately deep (90-120 cm)	Deep (more than 120 cm)
Celery	Chilli	Parsnip
Garlic		
Onion		
Parsley		

Relative tolerance of a few annual spices to soil acidity have been reported (Table 27).

Table 27. Relative tolerance of a few annual spices to soil acidity

Slightly tolerant (pH 6.8-6)	Moderately tolerant (pH 6.8-5.5)	Very tolerant (pH 6.8-5)
Celery, Salsify	Garlic Horse radish Parsley Chilli	Fennel

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