Compendium on

Recent Advances in Production & Processing of Spices

21st Jan to 4th Feb 2019

Organised by

iisr

ICAR-INDIAN INSTITUTE OF SPICES RESEARCH
Marikunnu, Kozhikode- 673012, Kerala

Sponsored by

MANAGE
मैनेज

NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT (MANAGE)
Rajendranagar – 500030, Hyderabad

Compiled and edited by:
P. Rajeev, C. Sarathambal, P. Umadevi, K. Anees & Sanil, P.C.

Chief Course Co-ordinator:
Dr. P. Rajeev

Course Co-ordinators:
Dr. P. Umadevi, Dr. K. Anees & Dr. C. Sarathambal

Published by :
The Director
ICAR-Indian Institute of Spices Research, Kozhikode

Home

CONTENTS

S. No	Title	Page No.
1	Spices Sector in India: Status, trends and challenges *Lijo Thomas and P C Sanil*	1-10
2	Turmeric genetic resources and varietal status *D Prasath, S Aarthi and B Sasikumar*	11-13
3	Crop improvement in ginger – Methods and Challenges *D Prasath, Muhammed Nissar, Sharon Arvind and HJ Akshitha*	14-21
4	Advances in crop management strategies in black pepper *C K Thankamani*	22-26
5	Potential for Tree Spices and its crop improvement *J Rema*	27-50
6	Organic farming in spices: Prospects and challenges *C K Thankamani*	51-56
7	Soil fertility management for enhancing spices productivity *V Srinivasan*	57-61
8	Diseases of Ginger and Turmeric *R Praveena*	62-66
9	Insect pests of spice crops and their management *C M Senthil Kumar*	67-72
10	Spices: secondary metabolites and medicinal properties *K Anees and T John Zachariah*	73-86
11	Bio- intensive pest management on Seed Spice Crops *Krishna Kant*	87-92
12	Mechanization in Spice Processing *E Jayashree*	93-105
13	Value Addition in Spices *E Jayashree*	106-115
14	ICAR-All India Coordinated Research Project on Spices *K Nirmal Babu and Sharon Arvind*	116-122
15	ICT Application in Agriculture Sector *V G Sunil*	123-126
16	Vanilla: Cultivation and Processing *R Ramakrishnan Nair*	127-151
17	Transfer of Technology & Extension for Spices Development- Institutions & Programmes *P Rajeev*	152-159
18	Technologies for commercialization *T E Sheeja*	160-182

Spices Sector in India: Status, trends and challenges

Lijo Thomas and Sanil P C
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

The fame of Indian spices, established over centuries of trade, has bestowed a well-deserved strategic advantage for spice exports from the country. Today, India is the largest producer, consumer and exporter of spices. Spice exports constitute nearly half of the country's horticultural exports. Spices are integral to human life – in tradition, food, aroma, health, and economy. Black pepper, ginger, turmeric, cardamom and tree spices such as nutmeg, cinnamon, garcinia and tamarind are the tropical spices of importance in Indian context. Coriander, cumin, fennel and fenugreek are important seed spices. Mint is an herbal spice of great importance in world market. Garcinia, black cumin, ajwain, saffron, mint, oregano, lavender, star anise are considered to be spices with immense market potential in future. The robust domestic demand for spices notwithstanding, a strong export market is important for sustained growth and development of the spices sector.

After consuming internally more than 70% of the spices produced, India still manage to be the largest exporter of spices in all its forms – raw, ground, and processed, and as active ingredient isolates. The recent trends in spice economy in general and the export sector in particular have been promising in terms of growth, diversification and unit value realization. The export volumes surged by nearly 30 per cent during the last five years. A key feature of the export growth in spices is the diversified nature of growth across crops and commodities. The export volume has increased for almost all the spice crops in the short run. This broad based growth is indicative of the sustainable nature of growth. Even with this backdrop of positive signals, it would be appropriate to undertake a review of the challenge faced by the spices sector, which has the potential to restrict the growth in the sector. The technological, marketing and technology dissemination challenges should be understood in the context of the extant socio-economic setting to make meaningful interventions aimed at the holistic development of the spices sector in the country.

A review of key trends in spices sector

a. Trends in area and yield

The spices sector is going through a period of robust growth in terms of productivity and export volumes. Though spice crops occupy only 1.6% of the gross cropped area, the area under spices has shown a positive trend in the recent years (Table 1). Though the area under black pepper declined significantly, the decline was compensated by a strong growth in yield. The positive trend in area expansion notwithstanding, it is the strong growth in yield that is noteworthy. Since the turn of this century, all the major spice crops have improved their productivity substantially. In fenugreek, the area grew by more than five time during the last two decades.

The strong growth trend in yield was visible across seed spice crops and other spices. Our analysis was mainly confined to the spice crops which occupy more than one lakh hectare at present. The compound annual growth rate of yield in spice crops since the turn of this century is significantly higher than the previous two decades (Table 2). For spices crop group as a whole, the CAGR grew from 2.72 in period I (1980-81 to 1999-00) to 3.18 during the second period (2000-01 to 2017-18)

Table 1: Changes in area and yield of selected spice crops

Crop	BE 2000-01		BE 2017-18		Percentage Change	
	Area (000 Ha)	Yield (Kg/Ha)	Area (000 Ha)	Yield (Kg/Ha)	Area	Yield
Black Pepper	206	294	135	448	-34.5	52.4
Ginger	84	3417	160	6505	90.5	90.4
Turmeric	166	4154	236	4919	42.2	18.4
Coriander	388	606	669	1293	72.4	113.4
Cumin	419	294	781	641	86.4	118.0
Chillies	898	1134	840	2797	-6.5	146.7
Fenugreek	36	1274	220	1415	511.1	11.1
Total Spices	2380	1310	4000	2128	68.1	62.4

Table 2: Trend in yield growth rate of spices

Crop	Period I (1980-81 to 1999-2000)	Period II (2000-01 to 2017-18)
Black Pepper	1.70	3.61
Ginger	2.92	4.33
Turmeric	3.88	1.70
Coriander	2.13	3.04
Cumin	-2.90	2.35
Chillies	2.82	4.13
Fenugreek	-1.03	0.03
Total Spices	2.72	3.18

b. Trends in spices export

During 2017-18, 1.08 million tons of spices and spice products valued at Rs. 20013.7 crores (US$ 2668.5 Million) has been exported from the country registering an increase of 9% in volume, 15.3% in terms of value over the previous year. Spices contribute 28.5% of the horticultural exports from the country and spices export occupies a prime place in terms of value after marine products, buffalo meat and basmati rice during 2017-18 and contributed 9.8% to the total agricultural products export. A key feature of the export growth in spices is the diversified nature of growth across crops and commodities. The export volume has increased for almost all the spice crops in the short run. This broad based growth is indicative of the sustainable nature of growth.

Another area of focus and importance in spices export development is the significant progress made in the exports of spice essential oils and oleoresins. The strong growth in processed food industry and pharmaceutical industry over the last decade has spurred the growth in exports of spice oils and oleoresins. The increased use of spice extracts in healthcare and wellness industry, along with growing body of research based evidence on therapeutic application of spice extracts can further strengthen this derived demand. During the last five years alone, the sector has grown by 55 per cent in terms of export quantity. The export of value added spice extracts enables the accrual of benefits along the value chain within the country and creates more employment opportunities in the spice agro-industrial processing sector.

c. Trends in processing and value addition

The lack of specific focus on value addition was one of the major drawbacks of the spices sector until recently. However, there are visible signs of focused efforts in value addition in spices sector. This focus is visible in the spices exports also with value added products gaining significant share in spices exports. Apart from spice essential oils and oleoresins, the curry powders, paste, sauces and mixed condiments and seasoning are gaining prominence in the spice export basket. The levels of value addition across spice crops also show considerable variation. In garlic, more than 52 per cent of the total exports are composed of value added products in value terms. In chillies, though the total volume of export is high, only less than 10 per cent value is derived from value added exports. Through concerted efforts in spice value addition, India has the potential to emerge as the hub of spice processing and value addition at the global level.

Technological challenges in spices production

The primary production technology for the spice crops has matured over the years and standard package of practices for almost all the crops are available. However, some of the technological challenges remain some of which are indicated below. These challenges are general in nature and they are described herein as serious limiting factors affecting spice output from the country.

- The ability of spice crops to produce sustainable yield levels in the events of weather aberrations and climate change scenario
- The conservation of genetic resources, bar coding and crop improvement using cutting edge technologies and application of the science of ‘omics’ need to be accorded priority.
- Application of DNA bar coding technology has demonstrated its utility in detecting adulteration in many spices. These technologies need to be validated and strengthened further to develop commercially viable technologies for easy detection of adulteration in spices.

- Lack of efficient protocols for fast breeding strategies to enhance the pace of varietal development
- The existing varietal breeding strategies and programmes are more focused on deploying yield enhancing and abiotic stress tolerance traits in crop varieties. Along with maintenance breeding for consolidating the productivity gains and abiotic stress tolerance, higher priority need to be accorded for development of climate-smart crop varieties.
- Research on new plant protection molecules for managing biotic and abiotic stress which can meet the compliance requirements of the increasing focus on food safety presents a significant challenge for the spice farming systems.
- The molecular characterization and profiling of high value compounds in spices is a work in progress and strategies for speeding up the process need to be put in place.
- Organoleptic profiling of spices across varieties and cultivars need to be undertaken to understand the range of spice flavours and specific profiles available with us. This will enable to identify niche markets for spices with specific profiles and flavour compositions.
- Pharmaceutical value addition in spices need to be given more thrust by creating better linkages between agricultural research agencies and institutions in the medical /pharma sectors.
- Prioritization of pesticide residue and contaminant problems and focused research initiatives on addressing identified constraints can go a long way in projecting India as a source for food safe spices.
- Abiotic stress tolerance in spices needs to be studied to develop better crop management strategies for climate aberrations and natural variability. This area of research can also strengthen the efforts to expand the crop ecological spread and geographical diversity in cultivated areas.
- Resource conservation strategies for enhancing use efficiency in and resource productivity need to be fine-tuned and deployed.
- Aggregation of multi-locational data on crop-weather interaction and crop-ecology interaction on to a single platform to generate useful data for developing crop management modules.

The technical and technological challenges described above are general in nature and not specific to crops. In each of the spice crops there are specific biotic and abiotic stress challenges which either require enhancement in effectiveness or require a paradigm shift in of management strategies adopted. However, the research establishment in spice crops spread across the country through a network of research centers under All India Coordinated Research Project on Spices (AICRPS) located across State Agricultural Universities and other research institutions is capable of addressing these challenges in a time bound manner.

Challenges in technology dissemination

The spice crops discussed herein have a long history of cultivation in India. In fact some of these crops originated in the Indian sub-continent. The long history of cultivation also means that there is a highly evolved system of cultivation practices associated with these crops. The challenge facing the modern technology dissemination system is to create and nurture viable technology intervention points while subsuming and strengthening the good elements of the traditional practices. The production of most of the spices is dominated by small holder production systems, where the set of challenges facing the technology dissemination efforts is crop and location specific. The suitability of the technologies for small holder production systems need to be evaluated critically before taking up dissemination of the technologies. Though many of the developed technologies are scale neutral, the prudent extension functionary will gauge the relevance and suitability of technologies with respect to the cost of adoption, incremental benefit cost ratio, technical ease of adoption and congruence of the technology with respect to the traditional practices in vogue.

The technology dissemination system in the country should take a careful note of the trends in the spices production and market demands to dovetail the extension activities to meet the felt and unfelt demands of the clientele. Some of the points for consideration for the spice extension system as whole are noted below. These issues outlined below should inculcated in the extension strategies for the future.

- Adulteration in spices is an age old problem which should be viewed as a corollary to the issue of food safety. The awareness on this issue among the spice farming community is low. Pesticide residues and mycotoxin contaminants in spice products along with lack of MRL and ADI standards for some of the pesticides used in spices is another issue related to food safety and spice trade. As a commodity with a strong export focus, spices sector need to gear up to the challenge of producing food safe spices.
- The increasing stringency of trade regulations of spices indicate the need to push for promoting good agricultural practices in spice cultivation.
- Spice crops are cultivated across wide agro-ecological niches and the value of output from unit area has been found to be favorable in comparison to cereals, pulses and oilseeds. This means that every opportunity to enhance the area under spices or for intensifying spice cultivation without compromising food security should be explored.
- The extant farming systems should be reviewed to explore the possibility of offering choices and alternatives to the farming community for enhancing the output in several spices through crop intensification, optimal intercropping strategies astute land use planning and value addition.
- The low level of awareness about good agricultural practices in spice production and post-harvest handling need to be addressed through innovative extension strategies.
- The high share of small holder producers in spice farming and low producer collectivization are challenges for extension systems in disseminating good agricultural practices.

- The emerging institutional arrangements for collectivization of production and processing like the Farmer Producer Companies along with reforms in the marketing institutions has given an outlet for the latent potential of the Indian spice economy, critically dependent on the small holder production system.

The crux of the challenge faced by the extension system can be summarized as the challenge for enabling the farmers and the farming systems to cope with the fast paced changes in climate, market institutions, information flows and technology without compromising sustainability and farm business income.

Marketing of spices as a challenge: some observations

Spices constitute a commodity group which is considered to be the most traded among the agricultural commodities. With this back drop, we might expect a highly evolved marketing system for the domestic and global marketing and trade of spices. However, as a nation we have so far failed to create a uniform market for spices. The time, space and location plays a significant role in marketing with the establishment of a single market within the country still remaining an unachieved goal.

The challenges in creating exportable surplus have been addressed to a considerable extent. The availability of spice produce in the country has been mainly fueled by the growth in yield rather than through area expansion route (Table 3). This trend needs to be supported by providing adequate marketing opportunities for the spices produced. The development of crop specific value chains for specific spice commodities should be given immediate attention to ensure spice crop production as an attractive crop choice.

Table 3: Role of area & yield growth in production of spices (2000-01- 2017-18)

Crop	Yield Effect	Area Effect	Interaction
Ginger	34	35	31
Turmeric	27	62	11
Coriander	42	27	31
Cumin	38	28	33
Chilly	112	-5	-7
Fenugreek	2	88	10
Spices Total	36	39	25

Note: Black pepper not included as the area was statistically revised during 2010-11

The increasing level of global competition and the vulnerability of domestic production sector to cyclical market price fluctuations in the international market should be viewed very seriously. The level of competitiveness of Indian spices should be studied to identify crops where significant productivity changes or cost reduction is warranted to remain competitive. Such crops should get focused attention in technology development initiatives. This is critical for spice production in the country to remain competitive at the global level by removing inefficiencies along the value chain.

The value of output per unit area is higher for spice crops in comparison with cereals, pulses and oilseeds (Table 4). This presents a good opportunity for enhancing returns from unit area by adopting suitable spice crops in the cropping pattern and crop mix. The spices also form a commodity group different from cereals in that they are high value-low volume commodities. This group of commodities would require a different marketing strategy and institutional arrangements to realize the full value of the commodity. The existing nature of functional distribution of benefits accrued along the spice value chains favours intermediaries and traders. The spice value chains need to be re-designed in manner favouring the primary producer so that the benefits from productivity enhancement and value addition can be diverted to the betterment of the farming community.

Table 4: Value of Output of selected spice crops (Rs/ha) BE 2015-16

Crop	Value of output (Rs/Ha)
Black Pepper	141100
Ginger	290978
Turmeric	274829
Coriander	36024
Cumin	87433
Chilly	172075
Spices & Condiments	154107
Paddy	38614
Wheat	35984
Sugarcane	114021
Oilseeds	36830
Pulses	20769

Note: Value of output at 2011-12 prices, Computed from data available with Central Statistics Office, Ministry of Statistics & Programme Implementation, Government of India

What do these trends and observations imply?

While all these present considerable challenges, there is a need to develop cutting edge technologies that are simple, cost-effective and farmer-friendly. With the projected increase in population and demand for spices, the productivity of spices need to increase by a factor of 2.7 to 5.7 from its present level to meet the local and global demand. Therefore, we need to continuously strive to increase spices productivity by enhancing input use efficiency, and reducing post-harvest losses with an eye on reducing the cost of production. These challenges can be met through exploiting latent potential in traditional research arenas and exploring innovative strategies. Some of the refreshing perspectives in spices are discussed below.

- Productivity enhancement through better input management/precision farming systems
- Varietal development focus on ideotype development for quality and climate resilience
- Prioritized research on bio-risk management to ensure the containment and management of biotic stress elements in spice crops
- Research on protected cultivation of spices for ensuring season independent availability of spices for household consumption and processing. Nurturing and improving sound techniques on precision farming, protected cultivation and urban horticulture can help in surmounting the challenges posed by other growing countries
- Enhancing the skill set of spice crops to tolerate/ circumvent climate change along with other abiotic stress factors commonly associated with spice crops
- New market oriented technologies for secondary agriculture and value addition
- Exploiting the potential of spices and spice extracts as nutraceuticals, functional foods and wellness products through intensified research in the area of high value compounds in spices for possible drug formulations.
- Development and deployment of human resource and technological capability in the niche areas of nutrigenomics and pharmacogenomics to harness the latent potential of bioactive compounds in spices
- Expanding the crop geography to non-traditional areas through strategic trait deployment in varieties

Focus areas for spices sectoral development for livelihood security

Each state cultivates one or the other spices. There are several spices which can be grown as rain-fed crop in high rainfall areas and as irrigated crops in less rainfall areas. Seed spices are very special in that they can luxuriantly grow in arid regions of the country using the residual moisture, especially in Gujarat and Rajasthan sustaining the livelihood and providing much needed income in rural areas of these states. Spices are high value and low volume commodities of commerce and have great potential in increasing the farmer's income substantially. They can be additional crop in most cropping systems and can give the extra income and in most cases without extra expenditure. Spice crops can play a significant role in our efforts targeted at enhancing farm income. Some of the urgent areas of focus in for promoting sustainable, equitable and stable in this sector include

- Establishment of small nurseries in farmers garden to help in production and supply of disease free planting materials of improved high quality varieties

- Increase productivity of spices through the deployment of superior high yielding high quality varieties and sustainable production technologies.

- Ensure monthly returns to small farmers and house holders through mixed cropping systems design and off season cultivation of seed and herbal spices supplemented by 'micronutrient fortification'. This also helps the micronutrient deficiency (hidden hunger) in communities.

- Introduce Spices including seed spices as inter crop in existing gardens where ever possible and in new plantations. The addition of a spice crop element should be targeted in 20 per cent of newly planted/ replanted area under plantation crops for increasing domestic availability of spices and farm income realization per unit area.

- Establishment of community storage, and processing facilities through collective cluster farming for better product development in quality and quantity and better remuneration . The emerging farmer collectivization institutions need to be strengthened.

- Hand holding for Market driven product development and Business Planning and Development (BPD), licensing of varieties, technologies products and a culture of agri - entrepreneurship among rural farmers and branding.

Conclusion

Spices are high value and low volume commodities of commerce in the world market and hence have great potential in increasing the rural farmer's income substantially. They can be additional crop in most cropping systems and can give the extra income and in most cases without extra expenditure. The growth of spices production will lead to a significant growth in on-farm employment opportunities. The spice industry is expected to create great employment potential as spices are labour intensive crops. Further, there is substantial scope for creating new jobs through value addition in spices.

The spice sector is one of the traditional but most important sectors of Indian agriculture, which has embarked on a journey of modernization and diversification to suit the market demands of the modern economies. The agricultural research system, which has provided unparalleled support for the growth and development of the spice sector over the years, should be further strengthened to provide innovative solutions to emerging challenges. Directed and focused research investment in varietal development for specific industrial traits, spice genomics and bio-informatics, high value compounds from spices, pharmacological properties of spices, development of ecologically sound crop protection modules, sustainable crop management strategies etc. is also required to sustain the growth in spices sector.

Selected References

Anandaraj M, R Dinesh, V Srinivasan, K Kandiannan, D Prasath (2014) Research and development in Spices at IISR – Status and challenges. In: (Dinesh R, Santhosh J Eapen, C M Senthil Kumar, K Prathapan, R Ramakrishnan Nair, T John Zachariah, M Anandaraj (Eds.)). Souvenir – PLACROSYM XXI, International Symposium on Plantation Crops, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India. pp. 119-134.

AISEF (2012) A report on the Indian Spice Industry, All India Spices Exporters Forum. www.aisef.org

Krishnakumar, N. K. (2015) Spices - Way forward, *in* Souvenir and Abstracts, National seminar on Spices and Aromatic crops(SYMSAC VIII), *Towards 2050- strategies for sustainable* *spices production* (KS Krishnamurthy et al eds), Indian Society for Spices, Kozhikode.P:3-14

Matthews, M. and Jack, M. (2011) Spices and herbs for home and market. Diversification booklet number 20, Food and Agriculture Organization of United Nations.

Parthasarathy, V.A., Srinivasan, V., Kumar, A and Bhat A I. 2007. *Vision 2025 – IISR Perspective Pla***n**. Indian Institute of Spices Research, Calicut (http://www.spices.res.in/downloads/vision2025.pdf

Spices Board of India, 2015, Spices Industry in India. Spices Board, Kochi

Directorate General of Foreign Trade (2018) Monthly bulletin on foreign trade Statistics, April 2018, Statistics Division, DGFT, Ministry of Commerce and industry available at http://dgftcom.nic.in/exim/2000/tradestat/mis/bapr18.pdf

http://commerce-app.gov.in/eidb/default.asp

http://indianspices.com/

Turmeric genetic resources and varietal status

D Prasath, S Aarthi and B Sasikumar
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Turmeric (*Curcuma longa* L.) is a rhizomatous herbaceous perennial plant belonging to the family Zingiberaceae, which is native to tropical South Asia. It grows in tropical and subtropical regions throughout the world and possesses high nutritional value. India is the main producer and exporter of turmeric in the world. It is commonly used as spice for flavouring and also as a natural colorant with a variety of applications such as its use as a condiment, in cosmetics and as a dye, besides being a potential source of therapeutically important molecules. The turmeric powder contains 2-8% curcumin, which is the main biologically-active phytochemical compound. Moderate genetic variability exists in the crop and cultivars vary in yield, cropping duration and quality. Clonal selection has played a significant role in developing several high yielding varieties.

The genus *Curcuma* comprises about 70 species. Due to the lack of a comprehensive taxonomic revision, there is still little consensus on the number of species that should be recognized. Out of the 100 or so species reported in the genus, about 40 are of Indian origin. It is widespread in the tropics of Asia to Africa and Australia. The highest diversity is concentrated in India and Thailand, followed by Burma, Bangladesh, Indonesia and Vietnam.

About 50 commercial types of turmeric are cultivated in India (Table 1). The popular local cultivars are essentially named after the places where they are grown. The cultivars are classified either as short, medium or long duration as well as having a high or low curcumin concentration. Existence of wide variability among existing cultivars in respect of growth parameters, yield attributes, resistance to biotic and abiotic stresses, and quality characters (Table 2) has been reported in turmeric.

Table 1. Traditional cultivars popularly grown in different turmeric growing states of India

State	Cultivars
Andhra Pradesh and Telangana	Duggirala, Mydukur, Armoor local, Cuddapah, Kodur, Tekurpet, Kasturi, Chayapasupu, Armoor, GL. Puram, Amalapuram, Rajapur, Nandyal, Avanigaddu, Vondimitta.
Tamil Nadu	Erode local, Salem local.
Assam	Shillong, Tall Karbi.
Kerala	Alleppy, Moovattupuzha, Wyanad local, Mananthody, Mannuthy local.
Maharashtra	Rajapuri, Sangli local, Sugandham.
North-East region	Lakadong, Aieng.
Odisha	Dindigam, Dubgi, Jobedi, Katingia.

Table 2. Variability for quality characters of different cultivars of turmeric evaluated in India

Characters	Range	Promising cultivars/accessions

Dry recovery (%)	13.5 - 32.4	Ernad, Cls No. 5A, Amrithapani, Kothapetta, Amalapuram Sel. III
Oleoresin (%)	10.0 - 19.0	Chamakuchi, Kayyam, Gudalur, Palani, Amalapuram Sel. III, Rorathong, E. Sikkim
Oil (%)	4.0 - 9.5	Ernad, Kakkayam local, Kahikuchi
Curcumin (%)	2.8 -10.9	Kaziranga, Jorhat, CIIs 328, Sugandam, Kayyam, Gudalur, Edapalayam, Erathukunnam, Palapally, Trichur

Breeding Methods

The main emphasis of turmeric crop improvement is on yield potential, high curing percentage, and high curcumin content. For many years, crop improvement in turmeric has been limited to clonal and seedling selection and mutation breeding. With the recent success of viable seed set in turmeric, recombinant breeding is also attempted in this clonally propagated crop.

Clonal Selection: Clonal selection has played a significant role in developing several high yielding varieties of turmeric. This was due to the characteristic of rare seed set and to insufficient knowledge about establishing seedling progenies. The selection was mainly applied to land races collected from different turmeric growing areas of the country. Three lines, PCT-8, PCT-13 and PCT-14 with high yield and curcumin content were released as 'Suvarna', 'Suguna' and 'Sudharshana'based on multi-location evaluation of 19 high yielding lines. 'Suguna' and 'Sudharshana' are both short duration varieties and are also field tolerant to rhizome rot. These were found to perform better than other cultivars in Andhra Pradesh. Two more high yielding and high quality varieties namely 'IISR Alleppey Supreme' and 'IISR Kedaram' were released through clonal selection. Considering yield and nematode resistance, two promising accessions Acc. 48 and Acc. 79 were identified; later Acc.48 was released as 'IISR Pragati'.

Seedling Selection: Reports on achieving seed set and enhancing seed germination opened up new vistas for crop improvement in turmeric. Evaluation of 15 open pollinated seedling progenies resulted in two promising lines which were released as 'IISR Prabha' and 'IISR Prathibha'. Thus, it is evident that seedling progenies have the potential to generate sufficient variability for selection of better genotypes for commercial cultivation.

Induced Mutation: All of the mutant cultivars that have been released were developed using X-ray irradiation. In Tamil Nadu, three mutants CO-1, BSR-1 and BSR-2 were developed from 'Erode local' subsequent to x-ray irradiation and selection, and these were released for large scale cultivation. 'Suroma' is another mutant selection produced from irradiating with x-rays. Induction of mutations, in combination with *in vitro* culture techniques, may be an effective approach for use in crop improvement in a vegetatively propagated crop like turmeric.

Hybridization: Proper study into incompatibility mechanisms and production of inbred progenies in turmeric may help in developing desirable recombinants and heterotic hybrids in turmeric.

The improved varieties of turmeric released from ICAR-Indian Institute of Spices Research, Kozhikode and AICRPS and their salient features are given in Table 3.

Table 3. Characteristics of improved turmeric varieties

Variety	Mean yield (fresh) (t/ha)	Crop duration (days)	Dry recovery (%)	Curcumin (%)	Oleoresin (%)	Essential oil (%)
ICAR-Indian Institute of Spices Research, Kozhikode						
Suvarna	17.4	200	20.0	4.3	13.5	7.0
Suguna	29.3	190	12.0	7.3	13.5	6.0
Sudarsana	28.8	190	12.0	5.3	15.0	7.0
IISR Prabha	37.5	195	19.5	6.5	15.0	6.5
IISR Prathibha	39.1	188	18.5	6.2	16.2	6.2
IISR Alleppey Supreme	35.4	210	19.3	6.0	16.0	4.0
IISR Kedaram	34.5	210	18.9	5.5	13.6	3.0
IISR Pragati	38.0	180	18.0	5.0	13.1	3.6
Tamil Nadu Agricultural University, Coimbatore						
CO 1	30.0	285	19.5	3.2	6.7	3.2
BSR 1	30.7	285	20.5	4.2	4.0	3.7
BSR 2	32.7	245	20.0	3.8	8.0	6.0
CO 2	42.0	250-260	20.0	4.02	8.0	5.0
High Altitude Research Station, OUAT, Pottangi, Odhisa						
Roma	20.7	250	31.0	6.1	13.2	4.2
Suroma	20.0	255	26.0	6.1	13.1	4.4
Ranga	29.0	250	24.8	6.3	13.5	4.4
Rasmi	31.3	240	23.0	6.4	13.4	4.4
Surangi	23.4	180-200	28.0	4.5-6.5	12.7	4.6
Tirhut College of Agriculture, RAU, Dholi, Bihar						
Rajendra Sonia	42.0	225	18.0	8.4	10.0	5.0
ICAR Research Complex for NEH Region, Shillong, Meghalaya						
Mega Turmeric 1	23.0	310	16.4	6.8	-	-
Kerala Agricultural University, Thrissur						
Kanti	37.7	240-270	20.2	7.2	8.3	5.2
Sohba	35.9	240-270	19.4	7.4	9.7	4.2
Sona	21.3	240-270	18.9	7.1	10.3	4.2
Varna	21.9	240-270	19.1	7.9	10.8	4.6
Sardarkrushinagar Dantiwada Agricultural University, Jagudan						
Sugandham	15.0	210	23.3	3.1	11.0	2.7
N.D. University of Agriculture & Technology, Kumarganj, Faizabad						
Narendra Haldi 1	35.0	200-210	19.08	5.0-6.0	9.80	2.0-3.0
Narendra Haldi 2	40.0	240-270	23.0	5.20	11.45	-
Narendra Saryu	30.0	250-260	19-21	5-6	12.0-14.0	6.0-7.0
Narendra Haldi 98	37.0	230-240	19-21	4.3-5.2	11.09-12.97	6.8-7.0
Dr. Y. S. R. Horticultural University,Turmeric Research station, Kammarapally						
Duggirala Red (JTS-6)	25	240-270	19.0	4.1	5.0	5.0

Crop improvement in ginger –Methods and Challenges

D Prasath, Muhammed Nissar, Sharon Arvind and HJ Akshitha
ICAR-Indian Institute of Spices Research, PO Marikuunu, Kozhikode – 673012

Ginger (*Zingiber officinale* Rosc.) (Family: *Zingiberaceae*) is a herbaceous perennial, the rhizomes of which are used as a spice. India is a leading producer of ginger in the world and during 2012-13 the country produced 7.45 lakh tonnes of the spice from an area of 157839 hectares. Ginger is cultivated in most of the states in India. However, states namely Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65 per cent to the country's total production.

Lack of seed set is a major handicap in sexual recombination. Hence all improvement work is purely on selection of clones. However, a few reported success are available on use of polyploidy and mutation. The major crop improvement objectives in ginger are high yield, wide adaptability, resistance to diseases (such as rhizome rot, bacterial wilt, and Fusarium yellows), improvement in quality parameters (oil, oleoresin), and low fiber.

Varieties

Several cultivars of ginger are grown in different ginger growing areas in India and they are generally named after the localities where they are grown. Some of the prominent indigenous cultivars are Maran, Kuruppampadi, Ernad, Wayanad, Himachal and Nadia. The exotic cultivar ‘Rio-de-Janeiro’ have also become very popular among cultivators.

Indigenous cultivars

Dry ginger: Maran, Wayanad, Manantoddy, Himachal, Valluvanad, Kuruppampady
Green ginger: Rio-De-Janeiro, China, Wayanad Local and Tafengiya

The improved varieties of ginger and their salient features are given in Table 1.

Table 1. Improved varieties of ginger

Variety	Fresh mean yield (t/ha)	Maturity (days)	Dry recovery (%)	Crude fiber (%)	Oleoresin (%)	Essential oil (%)
Indian Institute of Spices Research, Kozhikode – 673 012, Kerala						
IISR Varada	22.6	200	20.7	4.5	6.7	1.8
IISR Mahima	23.2	200	23.0	3.3	4.5	1.7
IISR Rejatha	22.4	200	19.0	4.0	6.3	2.4
High Altitude Research Station, Orissa University of Agriculture and Technology, Pottangi – 764 039, Orissa						
Suprabha	16.6	229	20.5	4.4	8.9	1.9
Suruchi	11.6	218	23.5	3.8	10.0	2.0

Suravi	17.5	225	23.5	4.0	10.2	2.1
Subhada	18.0	210	22.4	3.4	10.4	2.0
Sourabh	10.8	213	21.7	3.5	4.8	1.6
Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh – 173 230						
Himagiri	13.5	230	20.6	6.4	4.3	1.6
Solan Giriganga	20.0	220-230	21.1	4.5	4.7	1.5
Kerala Agricultural University, Thrissur – 680 656, Kerala						
Athira	21.0	220-240	22.6	3.4	6.8	3.1
Karthika	19.0	220-240	21.6	3.7	7.2	3.2
Aswathy	23.0	220-240	19.7	3.5	7.5	3.3
Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal						
Mohini	14.0	220-240	21.7	5.3	4.1	1.3

Crop-improvement work in ginger is constrained due to the absence of seed set. As a result, clonal selection, mutation breeding, and induction of polyploidy were the crop improvement methods employed. World ginger cultivars are summarized in Table 2.

Table 2. World ginger cultivars

Country	Cultivar
China	Bajpai, Bamboo Root, Burdwan, Chenggu Yellow, Dense-Ringed Delicate Fleshy, Fleshy, Fuzhou, Laifeng, Laiwu Big, Laiwu Slice, Maniyang, Red-bud, Red-claw, Sparse-Ringed Big Fleshy, Tongling White, Xingguo, Xuancheng, Yellow-Claw, Yellow-heart, Yulin Round Fleshy, Yuxi Yellow, Zaoyang, Zunyi Big White
India	Amaravathy, Ambalavayalan, Assam, Athira, Baharica, Bhaise, Chekerella, Chernad, China, Ellakallan, Ernad, Ernad Chernad, Gorubathani, Himachal, Himachal Local, Himgiri, Jorhat Hard Ernadan, Jorhat local, Juggigan, Karakal, Karthika, Kerala Local, Kunduli, Kunnamangalam, Kuruppampadi, Mahima, Mananthody, Maran, Mowshom, Nadan, Nadan, Nadia, Poona, Pulpally, Rejatha, Rio de Janeiro, Sabarimala, SG 692, SG61, Suprabha, Suravi, Suruchi, Swathing Pui, Thinglaidum, Thingpui, Thodupuzha, V3S1, Valluvanad, Varada, Wayanad, Wynad Kunnamangalam, Wynad Local, Zahirabad
Jamaica	Blue Turmeric, Bull Blue, China Blue, Red Eye, St. Mary
Japan	Kintoki, Oshoga,Sanshu, 4*x* Sanshu
Malaysia	Halyia, Halyia Udang, Halyia Bara, Pink, White Skinned
Nigeria	Taffingiwa, Yasun Bari
Philippines	Hawaiian, Native

Planting

Ginger is propagated by portions of rhizomes known as seed rhizomes. Carefully preserved seed rhizomes are cut into small pieces of 2.5-5.0 cm length weighing 20-25 g each having one or two good buds. The seed rate varies from region to region and with the method of cultivation adopted. In Kerala, the seed rate varies from 1500 to 1800 kg/ha. At higher altitudes the seed rate may vary from 2000 to 2500 kg/ha. The seed rhizomes are treated with mancozeb 0.3% (3 g/L of water) for 30 minutes, shade dried for 3-4 hours and planted at a spacing of 20-25 cm along the rows and 20-25 cm between the rows. The seed rhizome bits are placed in shallow pits prepared with a hand hoe and covered with well decomposed farm yard manure and a thin layer of soil and leveled.

Quality seed rhizome production

Ginger transplanting

Though transplanting in ginger is not conventional, it is found profitable. A transplanting technique in ginger by using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost. The yield level of ginger transplants is on-par with conventional planting system. The technique involves raising transplants from single sprout seed rhizomes in the pro-tray and planted in the field after 30-40 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds.

Technology

- Select healthy ginger rhizomes for seed purpose
- Treat the selected rhizomes with mancozeb (0.3%) and quinalphos (0.075%) for 30 min and store in well ventilated place
- One month before planting, the seed rhizomes are cut into single buds with small piece of rhizomes weighing 4-6 g.
- Treat the single bud sprouts (mancozeb 0.3%) for 30 min before planting
- Fill the pro-trays (98 well) with nursery medium containing partially decomposed coir pith and vermicompost (75:25), enriched with PGPR/*Trichoderma* 10g/kg of mixture
- Plant the ginger bud sprouts in pro-trays
- Maintain the pro-trays under shade net house
- Adopt need based irrigation with rose can or by using suitable sprinklers
- Seedlings will be ready within 30-40 days for transplanting

Practical tips on production of quality seed rhizomes in ginger

- Select soils with high organic matter content and good drainage with a soil depth of 30cm and pH of 6-7. Virgin forest soil rich in humus is the best soil.

- Do not cultivate ginger continuously in the same piece of land, a gap of two years may be given for cultivation.
- Adjust planting time in ginger so as to get moderate showers at the time of planting, plenty of rainfall during growth period and a dry period of one month prior to harvest.
- Take raised beds of 25 cm height and ensure proper drainage in the field.
- Mark healthy and disease free beds in the field when the crop is six months old and still green for collection of seed rhizomes.
- Use good quality seeds free from pests and diseases and treated with a fungicide and an insecticide.
- Use bio control agents like *Trichoderma* and *Pseudomonas* for the control of soil borne pathogens
- Grow green manure crops like daincha and sun hemp in the inter spaces for use in second mulching
- Adopt chemical and mechanical methods for the control of shoot borer
- Take all precautions for the control of soft rot and bacterial wilt diseases
- Do clean harvesting by removing small rhizome bits, pest and disease affected rhizomes completely from the plot.

Advanced methods of seed rhizome production

Hydroponics

The soil-borne disease and nematode problems are high in ginger production. Aeroponic cultivation of ginger can provide high-quality rhizomes that are free from pesticides and nematodes and produced in mild-winter greenhouses. The hydroponic system produced more yield and better quality rhizomes.

Hydroponics can be an alternative horticultural system for crops susceptible to soil-borne diseases. The uniform growing environment in a controlled greenhouse may produce crops with more consistent levels of secondary metabolites, which is of concern to the phytopharmaceutical industry. Unfortunately, there are few hydroponic or aeroponic production systems suitable for rhizome crops. Most hydroponic systems are designed for crops that produce fruit or leaf products and have fibrous root systems and a predictable crown size at the soil line. Rhizome-producing crops have special requirements, in that the horizontal growth habit of the rhizome needs room to expand and produce vertical shoots and secondary roots as needed, uninhibited by physical barriers.

Most commercial hydroponic systems utilize an aggregate growing medium, such as perlite or rockwool, contained in a plastic wrap or bag and are drip irrigated with a fertilizer solution. These systems provide sufficient aeration for the roots while physically supporting the plants. Non-aggregate systems, such as Nutrient Film Technique (NFT), Deep Flow or Ebb-Flood systems, are also popular commercially, but tend to minimize root growth and are dependent on a rigid plastic structure to support the plant at the crown. Aeroponics is another type of non-aggregate hydroponics, where the roots of the plants are suspended in an enclosed chamber and sprayed periodically with a fertilizer solution by means of a timer and pumps. Aeroponics offers several advantages over other hydroponic systems, particularly for root crops. The roots are easily accessible for monitoring, sampling, and harvesting. Without the buffering capacity of a solid or aggregate growing medium, the air/liquid medium of aeroponics permits precise control of the nutrient solution mineral composition and temperature. Finally, the common use of A-frame growing structures in aeroponics permits twice the growing area surface in the same size greenhouse, potentially doubling the economic yield for a grower. However, all aeroponic systems previously described in the literature require a rigid structure at the crown of the plant to support the plants while their roots are suspended in the fertilizer spray. This rigid support would restrict the horizontal growth habit of the rhizome. A new aeroponic system was needed to accommodate the horizontal nature and growth habit of a rhizomatous crop.

Preliminary observations in South Florida showed that costs of production were lower under hydroponic system due to reduced maintenance associated with diseases, insect and weed control. Hayden *et al*. (2004) in Arizona also tried soil less aeroponic cultivation of ginger to get high-quality rhizomes that are free from pesticides and nematodes in mild-winter greenhouses. The unique aeroponic growing units incorporated a “rhizome compartment” separated and elevated above an aeroponic spray chamber. Plants received bottom heat on perlite medium has showed accelerated growth and faster maturity. A noncirculating hydroponic Method was used at Hawaii to produce diseases free ginger seed production (Hepperly *et al*., 2003).

Advantages of greenhouse production

- A “clean start” is ensured by using clean seed rhizomes planted in a wilt-free greenhouse using a wilt free commercial growing medium.
- Seed-pieces are of high quality because the rhizomes are selected from second-generation plants of tissue- culture origin, which allows for elimination of the off type rhizomes that may be produced from first-generation tissue-cultured plants.
- Control over growing conditions is assured when the growing area is secured and protected from weather throughout the growing season, reducing the potential for accidental introduction of the disease.
- Production is “unitized,” in that each grow-bag is a production unit, allowing for quick removal from the area of a plant suspected of being contaminated.
- Materials and supplies are readily available.
- Wilt-free seed-pieces can be regenerated year after year.
- The facility and production system can be cleaned and disinfected for each growing season, eliminating the need to search for and prepare new land yearly.

- The value of investment in a greenhouse and benches can be depreciated through years of operation, and the yearly costs for heavy equipment for field preparation are eliminated.
- Grow-bags are topped with light-weight medium as the plants grow to simulate the hilling cultivation done in the field, eliminating the potential for root injury as an entry point for the disease.
- Use of light-weight planting medium provides for easy hilling, harvest, and cleaning; the medium is also readily removed and washed off, which is laboursaving and results in an excellent, clean appearance of the marketable rhizomes.
- High yields;
- The product is of high quality and free of bacterial wilt disease

The disadvantages of this system are (i) initial capital investment can be high for greenhouse or shelter structures, plastic composite benches, an irrigation system, pots, and clean potting medium; (ii) A reliable source of clean water is needed, preferably a piped-in “county” water source, (iii) The availability of wilt-free starters is currently limited, and (iv) Strict sanitation practices are needed to maintain greenhouse sanitation to prevent introduction of diseases.

Tissue culture

The cell and tissue culture techniques have immense advantage in this vegetatively propagated crop, mainly since the conventional breeding programs are hampered due to poor flowering, lack of fertility and natural seed set. It is propagated vegetatively through rhizome. The germplasm collections in clonal repositories are also seriously affected by fungal diseases. Moreover since pathogenic fungi, bacteria or viruses are readily transmitted through traditional practices, it was deemed important to develop *in vitro* propagation techniques and to make available for commercial use the pathogen free germplasm. Protocols for micropropagation, callusing, plantlet regeneration, meristem culture and microrhizome induction are optimized. The main advantage of *in vitro* methods are that it helps in isolating disease free plants from elite varieties and also helps in inducing variability leading to high yielding, high quality and disease resistant lines.

Microrhizomes

The low efficiency of vegetative propagation, susceptibility of rhizomes used for vegetative propagation to diseases and degeneration of rhizomes on long term storage coupled with poor flowering and seed set has affected ginger cultivation and breeding. These can all be easily overcome through the microrhizome technology. Microrhizomes resemble the normal rhizomes in all respect, except for their small size. The microrhizomes consist of 2 to 4 nodes and 1 to 6 buds. They also have the aromatic flavour of ginger and they resemble the normal rhizome in anatomical features in the presence of well-developed oil cells, fibres, and starch grains were observed. The microrhizome derived plants have more tillers but the plant height is smaller. *In vitro* formed rhizomes are genetically more stable compared to micropropagated plants. Seed rhizome weight was 2-8 g as against 20-30 g in case of conventionally propagated plants.

Microrhizome gave very high recovery though lesser yield per bed. Microrhizome also were genetically stable. This coupled with its disease free nature will make microrhizomes an ideal source of planting material suitable for germplasm exchange, transportation and conservation (Nirmal Babu *et al* 2005). It is paradoxical that in spite of the best protocols available, the use of microrhizomes as a commercial method of seed production has not been reported. The perfected technique needs undergo commercialization to reduce cost of production.

Seed village

Quality seed rhizomes are the key input for realizing potential productivity in ginger and turmeric. There is vast scope to produce and distribute quality seed rhizomess in these corps for which seed village concept is a noval and highly practical approach and needs to be promoted to facilitate production and timely distribution of quality seeds of desired varieties at village level. In this context, the concept of seed village which advocates village self-sufficiency in production and distribution of quality seeds is getting momentum.

Concept

- Organizing seed production in cluster (or) compact area
- Replacing existing local varieties with new high yielding varieties.
- Increasing the seed production
- To meet the local demand, timely supply and reasonable cost
- Self sufficiency and self reliance of the village
- Increasing the seed replacement rate

Features

- Seed is available at the door steps of farmers at an appropriate time
- Seed availability at affordable cost even lesser than market price
- Increased confidence among the farmers about the quality because of known source of production
- Producer and consumer are mutually benefited
- Facilitates fast spread of new cultivars of different kinds

Key references:

Hayden, A. L., Brigham, L. A. and Giacomelli, G. A. (2004) Aeroponic cultivation of ginger (Zingiber officinale) rhizomes. Acta Horticulturae, 659: 397-402.

Hepperly, P., Zee F T, Kai, R M, Arakawa C N, Meisner M, Kraky B, Hamamoto K M, and Sato D. 2004. Producing bacterial wilt-free ginger in greenhouse culture. Extension Service Bulletins. P.6. University of Hawaii at Manoa. Available online http://www.ctahr.hawaii.edu/oc/freepubs/pdf/scm-8.pdf (accessed on 29-2-2008).

Jayashree E, K Kandiannan, D Prasath, Rashid Pervez, B Sasikumar, CM Senthil Kumar, V Srinivasan, R Suseela Bhai and CK Thankamani (2015) Ginger (extension pamphlet). Indian Institute of Spices Research, Kozhikode, November, 2015. pp 12.

Parthasarathy VA, V Srinivasan, RR Nair, TJ Zacharia, A Kumar and D Prasath (2012) Ginger: Botany and horticulture. Hort. Reviews 39: 273-388, ISBN: 978-1-118-09678-9.

Prasath D, Kandiannan K, Srinivasan V, Leela NK, Anandaraj M. 2018. Comparison of conventional and transplant production systems on yield and quality of ginger (*Zingiber officinale* Rosc.). Indian Journal of Agricultural Sciences, 88(4): 615-620.

Ravindran, P.N., K.N. Babu and K.N. Shiva. 2005. Botany and crop improvement of ginger. p. 15-85 In: P. N. Ravindran and K. Nirmal Babu (eds.), Ginger–The genus *Zingiber*. CRC Press, Boca Raton, FL..

Sasikumar, B., K.V. Saji, Alice Antony, J.K. George, T. John Zachariah, and S. J. Eapen. 2003. IISR Mahima and IISR Rejatha - two high yielding and high quality ginger (*Zingiber officinale* Rosc.) varieties. J. Spices Arom. Crops 12:34-37.

Advances in crop management. Strategies in black pepper

Thankamani C.K.
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Black pepper (*Piper nigrum* L.) known as king of spices is grown for its berries extensively used as spice and in medicine. Kerala and Karnataka account for a major portion (92 per cent) of production of black pepper in the country. Black pepper is also cultivated in a limited extent in Tamil Nadu, Maharashtra, North eastern states, Andaman & Nicobar Islands. The crop is grown in about 1.28 lakh hectares with a production of 64,640 tonnes (DASD 2016). India is one of the leading producer, consumer and exporter of black pepper in the world.

Climate and soil

Black pepper is a plant of humid tropics requiring adequate rainfall and humidity. The hot and humid climate of sub mountainous tracts of Western Ghats is ideal for its cultivation. It grows successfully between 20° North and South latitude, and from sea level up to 1500 m above sea level. The crop tolerates temperatures between 10º and 40° C. The favourable temperature range is 23-32^{0}c. A well distributed annual rainfall of 125-200 cm is considered ideal for black pepper. Black pepper can be grown in a wide range of soils with a pH of 5.5 to 6.5, though in its natural habitat it thrives well in red laterite soils.

The black pepper growing areas in the West Coast of India include (i) coastal areas where black pepper is grown in homesteads (ii) midlands and where black pepper is extensively cultivated on a plantation scale and (iii) hills at an elevation of 800-1500 m above sea level, where the crop is mostly grown on shade trees in coffee, cardamom and tea plantations.

Varieties

A majority of the cultivated types are monoecious (male and female flowers found in the same spike) though variation in sex expression ranging from complete male to complete female is found. Over 75 cultivars of black pepper are being cultivated in India. Karimunda is the most popular of all cultivars in Kerala. The other important cultivars are Kottanadan (South Kerala), Narayakodi (Central Kerala), Aimpiriyan (Wynad), Neelamundi (Idukki), Kuthiravally (Kozhikode and Idukki), Balancotta, Kalluvally (North Kerala), Malligesara and Uddagare (Karnataka). Eighteen improved varieties of black pepper have been released for cultivation. Among the varieties released from ICAR-IISR, Pournami is tolerant to root knot nematode , IISR Shakthi is toerant to *Phytophthora* foot rot , IISR Thevam has field tolerance to *Phytophthora* may be used for cultivation so that disease incidence can be reduced.

Propagation

Cuttings are raised mainly from runner shoots, though terminal shoots can also be used.Rooted lateral branches are useful for raising bush pepper. For large scale production of planting materials rapid or serpentine method of propagation can be used.

Selection of site

The land that is proposed for planting black pepper should be cleared of weeds and undergrowth. In level and low lands proper drainage channels should be provided to prevent water stagnation during periods of high rainfall. Areas having 1%-3% slope are ideal for planting black pepper. Planting in slopes facing south should be avoided so that the vines are not subjected to the scorching effect of the southern sun during summer. In sloppy lands adequate soil and moisture conservation measures are to be adopted.

Standards

Providing of ideal supports /standards plays an important role in successful establishment of black pepper vines. The standards used for trailing black pepper vines are of two types namely, living and non-living. The non-living standards include reinforced concrete posts, granite pillars and teak poles. In homesteads gardens in Kerala, black pepper is usually trained on arecanut and coconut and also on mango, jack, etc. When inter planted in cardamom and coffee plantations, black pepper is trailed on various forest trees that provide shade.

On plantation scale, *Erythrina indica* is the common live standard planted for trailing black pepper especially in Kerala. *Erythrina* is prone for wasp *Quadristichus erythrinae* and nematode infestation which may kill *Erythrina*. The thornless or less thorn type *Erythrina subumbrans* was found to be free of infestation by *Erythrina* Gall wasp (Narayana and Dhanya 2014). Other common standards that can be used are *Garuga pinnata*, *Gliricidia sepium*, *Leucaena leucocephala*, *Ailanthus malabarica* and *Grevillia robusta*.

In case stems/stem cuttings of *Gliricidia sepium* or *Garcinia pinnata* are used they are to be cut to suitable lengths during March-April and stacked in shade. The stacked stems start sprouting in May. After the first rain in May-June the sprouted stems are planted at the edge of the pits dug for planting black pepper vines. The cuttings of standards are to be planted in narrow holes of 40 to 50 cm depth. The soil should be well pressed around the standards to avoid air pockets and keep the standards firm in the soil.

Spacing

Under mono cropping system the optimum spacing is 3 m x 3 m, which can accommodate 1100 standards/ha whereas in sloppy land 3 m x 2 m spacing is recommended.

Planting

Pits of 50 cm x 50 cm x 50 cm at a distance of 30 cm away from the base of supporting tree are taken with the onset of monsoon. The pits are filled with a mixture of topsoil, farmyard manure @ 5 kg/pit and 150 g rock phosphate. Neem cake @ 1 kg and *Trichoderma harzianum* @ 50 g may be mixed in the pit at the time of planting. Two rooted cuttings are planted individually in the pits on northern side of each standard. At least one node of the cutting should be planted below the soil for proper anchorage. Planting should be done during April-May after the receipt of a few pre-monsoon showers on suitable standards

Cultural practices

Training and Pruning

As the cuttings grow, the shoots are to be tied to the standards regularly using suitable materials for anchorage. Pruning of terminal shoot increased number of spikes produced and number of bearing laterals.

Shading

The young vines are to be covered with dry arecanut or coconut leaves or twigs of trees during summer which should be removed with the onset of rains. Shade regulation by pruning branches of standards in black pepper gardens during April-and July-August is an important cultural practice to allow sufficient light for crop growth and productivity and also to reduce the incidence of diseases.

Mulching

Mulching around the basins of black pepper vines with organic materials especially green leaves @10 kg/vine to a radius of 1 m is required at the end of North-East monsoon .Live mulch (cover crops) such as *Calapagonium mucanoids* and *Mimosa invisa* can also be grown to provide soil cover and to prevent soil erosion. These cover crops are to be cut back regularly from the base to prevent them from twining along with black pepper vines.

Irrigation

Irrigating black pepper vines @ 100 litres per vine (hose irrigation) once a week during summer is recommended for vines having more than three years old .The water is to be applied in basins taken around the plants at a radius of 75 cm. In case drip irrigation is adopted, 7 litres of water per day through drip during October to May is recommended.

Weeding

Weeds are a major problem in black pepper plantations that are not maintained properly. The weeds growing in the basins remove considerable quantities of moisture and nutrients and should be removed. Hand weeding in the basins and slashing in interspaces promotes growth and enhances yield in black pepper.

Manuring

Manuring and fertilizer application is critical for proper establishment and growth of plants. To correct acidity in soil, application of lime or dolomite @ 500 g/vine in April-May during alternate years is recommended. Organic manures in the form of cattle manure or compost can be given @ 10 kg/vine during May. Neem cake @ 1 kg/vine can also be applied. Recommended blanket nutrient dosage for black pepper vines (3 years and above) are as follows:

NPK 50: 50: 150 g/vine/year (General recommendation)
NPK 50: 50: 200 g/vine/year (for Panniyur and Kannur district in Kerala)
NPK140:55:270 g/pl /year (For Kozhikode district in Kerala)
Only one-third of this dosage should be applied during the first year, to two-thirds in the second year and the full dose is given from the third year onwards. The fertilizers are to be applied in two split doses, one in May-June and the other in August-September and sufficient soil moisture must be ensured. The fertilizers are applied at a distance of about 30 cm all around the vine and covered with a thick layer of soil. As the soil fertility will be varying with the agro ecological conditions or management systems, site specific nutrient management for yielding gardens based on their soil test results for major nutrient is advocated.

When biofertilizer like *Azospirillum* is applied @ 50 g/vine, the recommended nitrogen dose may be reduced by half. In soils that are deficient in zinc or magnesium, foliar application of 0.25% zinc sulphate twice a year (May-June and September-October) and soil application of 200 g/vine magnesium sulphate, respectively is recommended. Foliar application of micronutrient mixture specific to black pepper is also recommended (dosage @ 5 g/L) twice, starting at flowering and followed at monthly intervals for higher yield.

Cropping System

Crops such as greater yam, amorphophallus, ginger, turmeric, coleus, Hybrid Napier grass, guinea grass and congosignal grass are suited for intercropping in juvenile black pepper garden. In black pepper garden having more than 15 years old, maximum net return (2.7 l/ha was obtained by intercropping elephant foot yam. Among fodder crops, maximum yield and net income obtained from Napier grass. The varieties Sreekara, Subhakara and Panniyur-5 perform well as intercrops in coconut and arecanut gardens.

Harvesting

In India, the harvest season extends from November to January in plains and January to March in hills. During harvesting the whole spike is handpicked when one or two berries in the spike turn bright orange red. The spikes are nipped of by hand and collected in bags. Normally, single pole bamboo ladder is used as a support for harvesting. The berries are separated from the harvested spikes and dried in the sun for 7-8 days, on a clean concrete floor or bamboo mat till they are crisp and may be packed in gunny bags or paper bags after grading. The bags are arranged one over the other on wooden pallets after laying polypropylene sheets on the floor.

Potential for Tree Spices and its Crop Improvement

J Rema
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Introduction

About seventeen tree spices are grown in India. Among them nutmeg, cinnamon, cassia, clove, cambogia, kokam, tamarind and curry leaf are commercially important. The variability available in these crops is limited and also many species are becoming endangered and hence, conservation of the genetic variability in these crops is very important. The recent global developments and the loss in the genetic diversity has necessitated the development of programmes on conservation of biodiversity in tree spices and their sustainable use in agriculture as spice and medicine.

Collection and conservation of the biodiversity in tree spices has been one of the major mandates of Indian Institute of Spices Research (IISR), Calicut, Kerala, India. Conservation of tree spices is also being carried out by few State Agricultural Universities in India. The germplasm conservatories at IISR, Calicut consist of 1180 accessions of tree spices which includes all the major tree spices and their related taxa. This article deals with the diversity of tree spices (cinnamon, garcinia, kokum, nutmeg, clove and allspice) available in India, their conservation and crop improvement.

Cinnamon

The true cinnamon, *Cinnamomum verum* Bercht. & Presl. (Syn. *C. zeylanicum* Blume), (Lauraceae) commonly known as Sri Lankan cinnamon, is an evergreen tree reaching a height of 6-15 m, with bisexual flowers. Cinnamon of commerce is the dried inner bark of *C. verum*. Besides cinnamon, the bark oil, bark oleoresin and leaf oil are products sought after by the food, pharmaceutical and perfume industry for varied uses.

Species diversity

The genus *Cinnamomum* Schaeffer (Lauraceae) comprises about 250 species of trees and shrubs of tropics and subtropics. It is distributed in South-East Asia, China and Australia, growing mainly in tropical rain forests at varying altitudes. In India, it is represented by 26 species [Hooker 1886). Kostermans (1983) reported 12 species from South India. Many of the species of *Cinnamomum* have medicinal and spice value and are of great demand commercially. *C. verum* Bercht. & Presl (true or Ceylon cinnamon), *C. cassia* Presl. (Chinese cinnamon, *Cassia lignea*), *C. burmannii* Blume (Indonesian cassia), *C. loureirii* Nees (Vietnamese cassia), *C. tamala* (Buch-Ham.) Nees & Eberm. (Indian cassia, Indian bay leaf or tejpat), *C. camphora* (camphor tree) etc. are a few of the economically important species of the genus. The diversity in

Cinnamomum is mainly species diversity. As most of the species occur only in the wild, semi-domesticated gene pools of *Cinnamomum* do not occur.

The south Indian species and the north Indian species are distinctly different and are listed in Tables 1 & 2. A few species are reported to occur in both the places.

C. tamala, occurring mostly in the tropical and subtropical Himalayas and extending to north-east India up to an altitude of 2000 m, is the main source of the spice tejpat. It also grows in Nepal, Bangladesh and Myanmar. It is a moderate sized evergreen tree which is the source of *tejpat*, *tejpat* oil and Indian cassia bark. *Tejpat* is the dried leaf of *C. tamala* and *tejpat* oil is the oil obtained by distillation of the leaves. The dried bark of the stem is the Indian cassia bark. *C. tamala* is listed as a threatened species as the plant population is declining day by day due to over exploitation and habitat destruction in India.

C. camphora (camphor tree) are evergreen aromatic medium to large sized trees growing naturally in China, Japan, Taiwan and in the adjoining regions of South East Asia. In India, it is grown in a few plantations. It is used commercially for production of camphor which is used in the perfume industry..

Diversity analysis

In a cluster analysis of the south Indian species, *C. verum* was found to be more closely related to *C. malabatrum* (Shylaja 1984). Cluster analysis of the taxa using centroid linkage led to the grouping of *C. verum* with some collections of *C. malabatrum* while *C. cassia* and *C. camphora* formed unique groups. Principal component analysis was used to identify the characters responsible for species divergence. *C. camphora* formed a separate group from other species based on the bud type, stomatal type, phyllotaxy and epidermal thickness. *C. perrottettii, C. riparium* and *C. macrocarpum* formed another group based on the hairiness, hair size, and hair frequency. *C. cassia* diverged from the rest of species by the, nature and length of inflorescence. Species such as *C. camphora, C. cassia, C. riparium*, *C. macrocarpum* and *C. perrottettii* remained independent entities with respect to the principal component studied, thereby indicating their taxonomic independence. *C. verum* and *C. malabatrum* show considerable closeness, indicating their taxonomic affinity. Phenetic analysis of a large number of *Cinnamomum* spp. was carried out by Bakker *et al.* (1992) indicating ten clusters. According to this indication *C. burmannii* and *C. verum* are in Cluster 1, together with many other species. Within this cluster *C. burmannii* occupies an independent sub-cluster position, while *C. verum* is in another sub-cluster together with 21 other species (including *C. tamala, C. culitlawan*, *C. keralaense, C. sintok*, etc.). *C. cassia* formed a separate cluster.

Chemotaxonomy

Chemotaxonomical studies on *C. verum* and some of its related taxa occurring in the Western Ghats of Kerala, were carried out by Shylaja (1984) and Ravindran *et al*. (1992). They have analyzed flavonoids, terpenoids and steroids and found much variation among species. *C. verum, C. camphora, C. cassia* and *C. riparium* are chemically very distinct among themselves and from other species. Much infraspecific chemical variability was noticed in *C. malabatrum*. They also found that Sri Lankan and Indian accessions of *C. verum* were chemically identical. Infraspecific chemical variability exists in many species of *Cinnamomum.* Fujita (1967) attempted a sub-specific classification of many species based on volatile oil composition. Such infraspecific variability might have evolved as a result of interbreeding, segregation, chance mutations, and isolation mechanisms. The chemotypes of few *Cinnamomum* species are given in Table 3.

Based on the available data regarding the chemical composition of *C. tamala* leaf oils of both wild and cultivated sources it was found that various chemotypes exist. The various chemotypes are eugenol type (Gulati 1979, Hussain *et al* 1988), cinnamaldehyde type (Bradu and Sobti 1988) cinnamaldehyde-linalool type (Nigam and Ahmed 1990, Sood *et al*. 1979) and linalool type (Nath *et al*. 1994). The above analysis indicates that either different chemotypes exist or the species used for chemical analysis was taxonomically misclassified. The population of *C. tamala* growing in North East India has been classified into four distinct variants based on the leaf morphology and leaves of many related species are being sold in the market as *tejpat* (Baruah and Nath 2000). Nath *et al.* (1999) analyzed the four variants of *C. tamala* and reported the chemical composition of the leaf oil.

Cultivar Diversity

In India, high coefficient of variation for dry and fresh bark yield per plant, bark oleoresin, leaf oil, leaf size index and percentage recovery of bark was observed in cinnamon. Association analysis for nine characters in cinnamon revealed significant correlation of fresh weight of bark and leaf oil with dry; bark yield. Bark oil was negatively correlated with leaf oil (Krishnamoorthy *et al*., 1992). Correlation and path analysis studies conducted by Joy *et al.* (1998) indicated that the economic yield characters namely fresh leaf yield, leaf oil yield and eugenol yield were highly correlated among themselves. Plant height and canopy spread were highly and positively correlated with the yield component (Joy *et al*. 1998). In Sri Lanka, 8 different types of cinnamon based on their pungency of bark and petiole, texture of bark and structure of leaves are cultivated and they are known in Sri Lanka by their local names (Ranatunga *et al.* 2004).

Quality

Over 160 cinnamon trees of Indian origin and 66 trees of Sri Lankan origin were analyzed for their essential oil composition and oleoresin content. The Indian trees yielded bark essential oil in the range of traces to 4.28% and Sri Lankan trees in the range of trace to 3.85%. Indian collections had 21 elite trees yielding more than 2% essential oil from bark while in Sri Lankan collection such trees were five in number. Gas liquid chromatographic examination of the bark oil sample from the elite trees showed cinnamaldehyde to be the major content in both Indian and Sri Lankan trees; however, the percentage was much higher in Sri Lankan trees (70-84%) as against that in Indian trees (55-71%). The second major compound was eugenol in Sri Lankan trees constituting 5.0 -7.5% of the oil whereas in Indian trees, it was cinnamylacetate, which accounted for 4-26% of the oil. Eugenol was only the third or forth-major constituent in Indian bark oils varying generally from 2.5-5.4% in different lines with the exception of the top yielder from Indian collection with 11.6% eugenol. Acetone oleoresin yield varied from 5.8-19.0%. Compositional analysis of leaf oil samples showed Indian trees to contain more eugenol (83-93%) in their leaves compared to Ceylon collection (66-85%) (Babu and Krishnamoorthy 2002)

A study on seedling progenies of cinnamon revealed a clear variation in the performance of the progenies (Krishnamoorthy *et al.* 1991). Four different flush colours were noted among the cinnamon collections, *viz*., pure purple, purple dominated with green, green dominated with purple and pure green. The colour of young leaf flushes of cinnamon was found to be related to its quality. Krishnamoorthy *et al*. (1988) reported that the ratio of plants having young leaf flushes with purple and purple pigmented ones to green ones was 1:1. Plants with purple leaf flushes recorded about 29% more bark oil compared with green flushes, showing that flush colour may be taken as a criterion for selection of quality seedlings at the nursery stage.

The conservatory of tree spices at IISR, consists of seedling progenies of 26 Chinese cassia lines collected from Sri Kundara Estate, Valparai, Tamil Nadu. Quality analysis of these accessions revealed a high co-efficient of variability for bark oil and leaf oil (28.1% and 30.1% respectively) but the pungency and flavour of the accessions were more or less uniform as indicated by the cinnamaldehyde content. Bark oil ranged from 1.2 to 4.9%, leaf oil 0.4 to 1.6% and bark oleoresin 6 to 10.5%. The leaf and bark oils possess cinnnmaldehyde as the major constituent and few accessions C1, D1 and D3 were identified as superior, based on their overall chemical and flavour profile and regeneration capacity. (Krishnamoorthy *et al*. 1999).

High elevation species

C. wightii, C. perottettii **and** ***C. macrocarpum*** **are seen in Nilgiris at an elevation above 6000 feet.**

Rare and endangered species

Owing to severe deforestation there is every possibility of some species becoming extinct in the near future. The wild population of *Cinnamomum* is in real threat due to indiscriminate bark extraction from them. *C. nicolsonianum* Manilal and Shylaja and *C. heynianum* are reported as endangered. *C. nicolsonianum* is a very rare and endangered species having large leaves and very small axillary panicles that are few flowered which occur in low elevations in Western Ghats. The tree is extremely rare and is possibly in the verge of extinction (Manilal and Shylaja 1986). *C. sulphuratum*, which was listed as red listed spices in found in abundance in Kemmangundi (Western Ghats).

Varieties

At present there are 7 varieties of cinnamon released from various institutes in India. They are IISR Navashree and IISR Nithyashree (Indian Institute of Spices Research Calicut.), YCD-1(Horticultural Research Station, Yercaud, Salem District), PPI (C) 1 (Horticultural Research Station, Pechipari, Kanykumari District) Konkan Tej (Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra), RRL (B) C-6 (Regional Research Laboratory, Bhubaneswar, Orissa) Sugandhini (Regional Research and Medicinal Plants Research Station, Odakkali, Ernakulam District, Kerala).

Conservation

The conservatory of Cinnamon at IISR, Calicut includes *C. verum, C. cassia*, *C. camphora* (an economically important tree yielding camphor oil), *C. citriodorum*, lemon grass oil smelling *Cinnamomum* spp. Collected from Munnar (Idukki District) *C. malabatrum, C. perrottetti, C. wightii, C. macrocarpum, C. sulphuratum, C. riparium and C. tamala.* (Table 4). The germplasm of cinnamon are also assembled at Konkan Krishi Vidyapeeth, Dapoli, Maharastra, Tamil Nadu Agricultural University (Horticultural Station Yercadu), Regional Research Laboratory, Bhubaneswar and Kerala Agricultural University (Odakkali).

Table 1. Distribution of *Cinnamomum* species in South India

***Cinnamomum* species**	**Place of distribution**
C. chemungianum Mohan & Herry	Western Ghats
C. filipedicellatum Kosterm.	Western Ghats, Anamalais, Nilgiris
C. goaense Kosterm	North Western Ghats
C. gracile Hook. f.	Western Ghats
C. heyneanum Nees	Western Ghats
C. keralaense Kosterm.	Western Ghats

C. macrocarpum Hook. f.	Nilgiris, Anamalais
C. malabatrum (Burm.f.)BI.	Western Ghats
C. nicolsonianum Manilal & Shylaja	Western Ghats
C. perrottettii Meissn.	Niligiris, Western Ghats
C. riparium Gamble	Niligiris, Western Ghats
C. sulphuratum Nees	Western Ghats
C. travancoricum Gamble	Western Ghats
C. verum Brest. & Presl.	Sri Lanka, Western and Eastern Ghats
C. walaiwarense Kostern	Western Ghats
C. wightii Meissn.	Niligiris

Table 2. Cinnamomum *species available in North India*

Species	**Distribution**	**Major constituent**
C. assamicum	North East India	-
C. bejolghota (Buch-Ham)	Eastern Himalayas, Myanmar	1, 8- cineole, Linalool
C. camphora (L.) Bercht & Presl.	Sub-Himalayan region	Camphor
C. cassia *(L.) Brecht & Presl.*	Mizoram	Cinnamaldehyde
C. cecidodaphne Meissner	Eastern Himalayas	Cineole, Methyl cinnamate
C. glanduliferum Nees	Himalayas, Khasi Hills	Cineole, Terpineol, Camphor
C. impressinervium Meissner.	North east India	Eugenol
C. iners	Assam	-
C. parthenoxylon	Shillong, Meghalaya	-
C. pauciflorum Nees	North East India	Cinnamaldehyde
C. sulphuratum Nees	North Cachar Hills, Assam, Western Ghats	Linalool, Citral, Cinnamaldehyde

C. tamala Nees	North East India, Assam	
C. verum	North East India	Cinnamaldehyde

Table 3. Chemotypes of Cinnamomum *species*

Species	**Chemotypes**
C. bejolghota	Linalool type, Linalool –terpineol type, Linalool –phellandrane type
C. bodinieri	Citral type, Camphor type,
C. cecidodaphane	Methyl eugenol type, Safrole type
C. culitlawan	Safrole type, Eugenol type,
C. glanduliferum	Safrole type, Methyl eugenol type, Methyl eugenol + Safrole type
C. sulphuratum	Linalool type, Citral type, Cinnamaldehyde type, Methyl cinnamate type
C. tamala	Eugenol type, Cinnamic aldehyde type, Linalool type, Cinnamic aldehyde + Linalool type
C. verum	Cinnmic aldehyde type, Cinnamic aldehyde + eugenol type, Cinnamic aldehyde + Safrole type
C. wilsonii	Citral type, Cinnamicacetate type, Cinnamic aldehyde + Safrole type
Cinnamomum camphora	Camphor type, Linalool type, Cineole type, Safrole type, Borneol type,

Table 4. Genetic resources of tree spices conserved at Indian Institute of Spices Research, Calicut

Crop	Areas Surveyed	Important species
Cinnamon and Cassia	Calicut, Wyanad, Ernakulam, Kottayam (Kerala); Kanyakumari, Anamalai, Kolli and Shevroy Hilld (Tamil Nadu); Kodagu (Karnataka); Ratnagiri (Maharashtra); Meghalaya (North East India) Andaman and Nicobar Islands.	*Cinnamomum camphora* *C. cassia* *C. citriodorum* *C. filipedicellatum* *C. glaucescens* *C. macrocarpum* *C. malabatrum* *C. perrottetti* *C. riparium* *C. sulphuratum* *C. tamala* *C. verum* *C. wightii*
Nutmeg	Thenmala, Cheekilodu, Balussery, Mannuthy, Sugandhagiri, Munnar (Kerala); Nagercoil, Kolli and Shevroy Hills (Tamil Nadu); Ratnagiri (Maharashtra) Andaman and Nicobar Island	*Myristica amygdalina* *M. andamanica* *M. attenuate* *M. beddomeii* *M. fatua var. magnifica* * *M. fragrans* *M. malabarica* *M. prainii* *Gymnocranthera canarica* *Knema andamanica*
Clove	Ambanadu Estate, Quilon, Wyanad, (Kerala); Kolli and Shevroy Hills, Nagercoil (Tamil Nadu); Ratnagiri (Maharashtra).	*Syzygium aromaticum* S. *caryophyllatum* S. *cuminii* S. *fruiticosum* S. *heynianum*

		S. *jambolana* S. *jambos* S. *lanceolatum* S. *zeylanicum* *Eugenia uniflora*
Allspice	Ambalavayal, Mannuthy, Kanyakumari (Kerala)	*Pimenta dioica*
Garcinia	Kasaragod, Chembanode, Kozhikode, Kumarakam, kannur, Silent Valley, Thaliparamba, Thrissur (Kerala); Moodabidri, Puttur, Pudhuvethu, Sediapur, Kidu, Mercara (Karnataka) Vengurla (Maharashtra) Andaman and Nicobar Islands.	*Garcinia cowa* *G. gummi-gutta* G. *heynianum* G. *hombroniana* G. *imberti* G. *indica* G. *malabarica* G. *mangostana* G. m*orella* G. *tinctoria*

Garcinia

Species diversity

The genus *Garcinia* (Cluciaceae) includes more than 200 species of trees and shrubs, distributed in the tropics of the world chiefly in Asia and Africa. About 35 species are reported to exist in India including some exotic ones many of which are economically important. Out of 35 species reported to exist in India, 7 are endemic to Western Ghats, 6 in Adaman and Nicobar Island and 4 in North East India (Rodrigues, 2001). Some of these are detailed in Table 5. The genus *Garcinia* includes *Garcinia atroviridi, G. dulcis, G. echinocarpa, G. gummi-gutta, G. hombroniana, G. indica, G. lanceaefolia, G. livingstonei, G. mangostana, G. microstigma, G. morella, G. paniculata, G. pedunculata,, etc*. These species can be useful as sources of gamboges, dyes, hydroxyl citric acid (HCA), as good rootstock or for breeding purpose. Among the commercially important species, *G.gummi-gutta* and *G. indica* are cultivated mainly for their spice, which is obtained from the dried rind. *G. mangostana* and *G. morella* are also cultivated to a certain extent for their fruit and gamboges respectively. However, little attention has been given to document, and conserve the other economically important species of this genus in the era of Intellectual Property Rights and Biodiversity Conservation.

Garcinia indica Choisy (Kokum) is an evergreen graceful tree growing with conical canopy attaining about 10 meters in height. The main shoot is orthotropic whereas branches are plagiotropic exhibiting branch dimorphism. Three sex forms are seen in Kokum namely female, male and hermaphrodite types though it is generally reported to be dioecious. The dried rind of its fruit is the traditional ‘kokum’ or ‘binda’ of commerce used for garnishing curries. It is a popular tree spice having tremendous potential and also has many medicinal properties. In South India, it is used instead of tamarind in curries. The juice of the fruit is used as a mordant and the expressed oil of the seed is the kokam oil of the natives, extensively used to adulterate ghee. The seeds of the fruits yield valuable edible fat known in commerce as kokam butter. The recent understanding on the effect of hydroxyl citric acid (HCA) in preventing obesity in humans has boosted its economic value due to it’s HCA content. It is also the richest source of red pigments in the plant kingdom. The tree grows extensively in the Konkan region of Maharashtra, Goa, coastal areas of Karnataka and Kerala, evergreen forests of Assam, Khasi, Jantia hills, West Bengal and Gujarat. Kokum’ or *Garcinia indica* Choicy is a spice with great medicinal values occurring in the western coast in a semi wild state. It is a native of Western Ghats of Kerala (India) and Malaysia. It grows in the evergreen forests of the Western Ghats in South India and its habitat extents from Konkan southward to Travancore and into the Shola forest of Nilgiris where it can reach an altitude of up to 2000 m above mean sea level. In Kerala, it is very popular in the Central Travancore areas and Kerala seems to be one of the centers of origin of cambodge (*G. gummi-gutta*) where maximum diversity is seen. It is fairly common and abundant in the forests of western Sri Lanka from sea level to 600 m and in Malaysia. It is widely distributed in the evergreen forests of Western Ghats from South Kanara and Mysore to South Kerala up to the low lying reclaimed lands bordering the backwaters. The kokum is very common in the region of the west coast of India from S. Kanara onwards towards north. In Kerala the tree is quite rare except as few trees in state agriculture farms. The tree is also reported to exist in Mysore, Coorg and Wyanad.

G. gummi-gutta is found commonly in the evergreen forests of Western Ghats, from Konkan south to Travancore and in the shoal forests of Nilgiris up to an altitude of 600 feet. In Western Ghats of Kerala, 'kudampuli' grows at an altitude of 1300 to 2000 m above MSL. The best suited regions for its growth are those having high humidity and an altitude of 400-100 m. It is a small or medium sized tree with round crown and horizontal or drooping branches, levels dark green and shining, elliptic obovate, 5-7 cm long and 2.5-7.5 cm broad, fruits yellow or red when ripe, with 6-8 grooves ; about 6-8 seeds, surrounded by a succulent aril.

Cultivar diversity

Kokum

Good variability in vegetative and reproductive characters has been reported in kokum. This variability is of great use in the improvement of the crop in the coming years. Most of the collection of variability is being done by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharshtra, followed by ICAR research complex, Goa and University of Agricultural Sciences (USA), Dharward. Since grafts are to be planted, selections with orthotropic growth pattern need to be collected. Male, female and hermaphrodite sex forms are recognized. From Ratnagiri, Karnik *et al*. (2001) recorded 11 flower types and hermaphrodite type was actually located for the first time from here. Generally the fruits mature by late May or June that interferes with harvesting and processing. The preference is for early maturing types. Shinde *et al*. (2001) has reported the occurrence of early maturing types (February- March). Excellent variability for various fruit characters are reported. The colour varies from bright red, dark purple, white or even lemon yellow. However only the red forms have commercial value. Gradations in red colour are seen. Another character is big size or boldness. Generally the fruit weight is only 34.0g. The rind is quite thin (5mm) whereas thick skinned types (> 50mm) are preferred and are available. Gawanker *et al.* (2001) reported a promising thick rind type MLDK-5, which is under evaluation, out of five selections made at Ratnagiri. Though fruits are acidic, sweet forms are also reported, which may be as good as mangosteen as dessert fruit. Fruit flies are the most important pests and selection needs to be made for resistant types. Based on earlier studies one selection has been released as Konkan amruta by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Garcinia

Trees differ in size, shape and bearing habit. Some trees bearing fruits through out the year have been observed. The trees vary with regard to the flowering habit also. Dioecious and hermaphrodite types are seen. Lot of variation exists with regard to number of fruits, fruit size, shape, number of seeds per fruit and weight of fruit and seed. Seedless types are also observed rarely. The hydroxycitric acid content in the cultivars also vary significantly.

Conservation

Currently collection of biodiversity in kokum is actively being persued by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra in the Konkan region. Several clones are already under evaluation. However, the variability in South Canara types is yet to be collected. The variability in Goa is being collected by ICAR Research complex for Goa at Old Goa. Some collections also have been made by UAS, Dharwar. The Indian Institute of Spices Research, Calicut, (Table 4), National Bureau of Plant Genetic Resources (NBPGR) Regional Station at Trichur and the Regional Agricultural Research Station at Kumarakom are engaged in collection of biodiversity of all Garcinia especially Kokum and Cambogia. More surveys need to be concentrated in the South Canara district for collection of biodiversity of kokum. The variability of other species in the Andaman and Nicobar Islands and in the North Eastern States of India need to be collected for conservation. The correct identities of many species also need to be confirmed. NBPGR, Indian Institute of Spices Research (IISR) and Botanical Survey of India can mobilize necessary resources in the collection and conservation of the existing variability of kokum and other *Garcinias* in the country. A free exchange of germplasm by the forest departments of various states is also necessary to achieve the objective of kokum improvement.

Rare and endangered species

Garcinia mestonii. Bailey found in Australia has been identified as a rare species (Hammer and Khoshbakht 2005) and *G. indica* which was listed in the red list in Charmandi (Western Ghats) is at present found in abundance there.

Table 5: Important *Garcinia* species available in India

Species	**Distribution**
Garcinia andamanica King	Andaman Islands
G. anomala Planc.	Khasi Hills
G. atroviridis Griff.	North Eastern districts of Assam
G. cornea L.	Bengal
G. cowa Roxb. (G. kydia Roxb)	Eastern parts of India, Assam, Bihar Bengal, Orissa, Andaman
G. dulcis (Roxb.) Kurz	Introduced into India from Malaysia
G. echinocarpa Thw.	Tirunelveli forests

G. gummi-gutta (L). Robsmall [G. cambogia(Gaetn) Desr.]	Western Ghats, Maharashtra, Goa, Karnataka,Kerala, Shola forests of Nilgiris.
G. hanburyii Hook.	South India
G. hombroniana Pierre	Nicobar Island
G. imbertti Bourd	S. India
G. lanceaefolia Roxb.	Assam, Khasi Hills
G. livingstonei T.Anders.	Introduced to India form East Africa
G. malabarica Talbot	S. India
G. mangostana L.	Introduced to S. India
G. microstigma Kurz	Andaman Islands
G. morella Desr.	Assam, Khasi Hills, Western Ghats
G. paniculata Roxb.	Foot hills of Himalayas, Assam, Khasi Hills
G. pedunculata Roxb.	Assam, Manipur
G. speciosa Wall.	Andaman islands
G. spitcata Hook. [*G. ovalifolia* Hook. f.]	Western Ghats form Konkan Southwards
G. stipulate T. Anders.	Eastern Himalayas
G. succifolia Kurz	S. India
G. travancorica Beddome	Western Ghats
G. wightii T. Anders.	S. Indian Forests
G. xanthochymus Hook. [*G. tinctoria* Wight *G. pictorius* Roxb.]	Eastern Himalayas, Western Ghats, Andaman islands

Nutmeg

Nutmeg (*Myristica fragrans* Houtt.) is an important tree spice, yielding two spices, namely, the nutmeg (dried seed) and the mace (dried aril surrounding the seed). It is an evergreen, conical tree reaching a height of 10 metres, belonging to the family Myristicaceae.

Species diversity

The primitive family Myristicaceae, has about 18 genera and 300 species. The members of the family are pantropical, being associated with the rainforests of Asia, Africa, Madagascar, South America and Polynesia. India has four genera namely *Horsfieldia, Gymnacranthera, Knema* and *Myristica* and altogether 15 species. Table 6. Indicates the wild and related spices of Myristicaceae occurring in India. The members occur in the evergreen forests of Andaman and Nicobar Islands, Meghalaya and the Western Ghats. *Myristica* with 120 species is the largest of the genus and New Guinea has the largest number of species.

Nutmeg is indigenous to the Moluccas islands in Indonesia. Semi-domesticated gene pools of *Myristica* species do not exist as most of these species occur in the wild. *M. fragrans* is typically dioecious, with male and female flowers on different trees. Occasionally, male trees carrying a few female flowers are observed. Hermaphrodite trees having bisexual flowers are rarely noticed. Nutmeg is cultivated in Ernakulam, Trichur, Kottayam and Trivandrum districts of Kerala and also in few areas in Tamil Nadu, Karnataka, Maharashtra, Goa, Andhra Pradesh, North East *ndia* and Andaman and Nicobar Islands. The oldest nutmeg populations in Kerala are in Kalady and Pala and are reported to be more than 150 years old. Nutmeg is usually grown in river banks as it grows luxuriously in silts deposited by rivers. It is reported to be wind pollinated, Inflorescence is branched raceme in male and simple cyme in female. The male inflorescence has more number of flowers (up to 10) while female is less (up to 3).

Ecosystem diversity

The *Myristica* swamps are dominated by members of Myristicaceae. Krishnamoorthy (1960) reported *Myristica* swamp, for the first time, as a special type of habitat from Travancore. These swamps were found in the valleys of Shendurney, Kulathupuzha and Anchal forest ranges in the southern Western Ghats. *Myristica* swamps are also reported in Uttara Kannada District of central Western Ghats in Karnataka. These swamps are isolated and situated in localities from near sea level to about 450 m altitude. The northernmost swamp known is associated with a sacred grove in the Satari taluk of Goa. *Myristica* swamps are also reported from New Guinea (Corner, 1976).

The Western Ghats have three genera and five species of Myristicaceae; all of them are trees associated with evergreen to semi-evergreen forests. Of these *Gymnacranthera canarica* and *Myristica fatua* var. *magnifica* are exclusive to the swamps. *M. malabarica* is occasional in the swamps and more frequent in the evergreen forests. *M. malabarica*, often produce stilt roots and flying buttresses, even though it is seldom associated with swamps, indicating its possible origin in the swamps. Myristicaceae was the most dominant family of the swamps forming 32% of the total number of trees. Within the Myristicaceae,. *G. canarica* accounted for 78%, followed by *M. fatua* var. *magnifica* (19%), *K.. attenuata* (2%) and *M. malabarica* (1%). Since two species namely. M. *fatua* and *G. canarica* seem to be the most characteristic of *Myristica* swamps, the distribution of these species can be considered as an indicator of the distribution of *Myristica* swamps.

Cultivar diversity

In a study to identify the sex segregation in nutmeg, it was observed that out of 90 progenies, 40 were males, 45 females and 5 bisexuals. A preliminary analysis of genetic variability in 28 trees (14 years old) indicated some variability only for fruit number per tree. Correlation analysis revealed a significant negative correlation of fruit number per tree and mace weight. However, seed weight had a positive significant correlation with mace weight (Krishnamoorthy *et al*., 1991).

In a more systematic study on genetic variability of nutmeg, progenies from 16 mother trees of different localities (five progenies for each mother tree), lack of adequate genetic variability was evident for many of the important attributes. This particular study revealed that even though morphological variation exists for leaf shape, canopy shape etc. in nutmeg populations, exploitable genetic variation of crop improvement in nutmeg is lacking (Krishnamoorthy *et al*., 1996).

Progeny evaluation aims in analyzing breeding behaviour of certain elite trees for sex ratio and prepotency so that such promising trees are selected for seed/scion collection. Significant differences were observed among the populations for plant height, number of main shoots, number of years for flowering, fruit weight and ratio of mace weight to seed weight. The phenotypic coefficient of variation is more than the genotypic coefficient of variation, indicating the role of environment in the expression of these characters.

Additive genetic factors are attributed for the variations due to the comparatively low estimates of heritability and genetic advance of these traits. Mace weight to seed weight ratio has a very high heritability and very good genetic advance. Hence, selection for this trait may be very effective. Non-significant variation was observed for canopy size, number of erect shoots, number of fruits, girth etc. This may be due to the narrow genetic pool introduced into India, from which the present day population evolved. Therefore there is an urgent need to introduce genetic variability.

The variability of growth, flowering, and fruit set of 39 seedling progenies of nutmeg was studied at Ratnagiri, Maharashtra. Considerable amount of variation among the genotypes with respect to growth parameters was noticed. High magnitudes of phenotypic coefficient of variation and genotypic coefficient of variation indicated good amount of variation among the genotypes for these characters. High estimates of heritability and genetic advance for fruit set suggested that it is under the control of additive gene action (Haldankar *e. al.* 2004).

Promising accessions

Few nutmeg accessions (A9-4, A9-20, A9-22, A9-25, A9-79, A9-86, A4-12, A4-22, A4-52, A11-29, A11-70) were identified as promising at IISR, Calicut. Five accessions namely N-72, N-29, N-70, N-49 and N-74 were identified as promising from College of Agriculture, Dapoli (Haldankar *et al.* 2004). A super clonal selection A9-4 has been released as IISR Viswashree from Indian Institute of Spices Research, Calicut. A hermaphrodite variety Kokan Suganda has been released from Konkan Krishi Vigyan Peeth, Dapoli.

Quality lines

Sixty-five nutmeg germpalsm accessions conserved at Indian Institute of Spices Research were evaluated for chemical composition of nutmeg and mace and high variability was observed among the accessions. The essential oil content ranged from 3.9% to 16.5% in nutmeg and 6% to 26.1% in mace. Myristicin content ranged from 1.1% to 45.6% in nutmeg oil and 0.21% to 36.6% in mace oil; the elemicin content. ranged from 1.0% to 29.7% in nutmeg oil and 1.0% to 30.2% in mace oil. Safrole content ranged from 0.1% to 22.1% in essential oil and 0.2% to 21.8% in mace oil. (Maya *et al.* 2004).

Accessions with high oil yield in nut and mace, high butter content, high oleoresin in nut and mace, high myristicin and elemicin, low myristin and elimicin etc. has been identified from the germpalsm available at Indian Institute of Spices Research and the details are given in Table 7.

Table 6. Members of *Myristicaceae* occurring in India

Members of Myristicaceae	**Distribution**
Myristica amygdalina Wall.	Nagercoil
M. andamanica Hook. f.	Andaman Islands
M. attenuate Wall.	Western Ghats
M. beddomeii King	Western Ghats
M. dactyloides	Western Ghats
M. gibbosa Hook. f. & Thoms.	Khasia Mountains
M. glabra Blume	Silhet (Assam), Tinnevelly (Tamil Nadu), Andaman Islands
M. glaucescens Hook.f. & Thoms.	Tinnevelly, Andaman islands
M. irya Gaertn. Fruct.	Tinnevelly, South Andaman islands
M. kingii hook. F.	Sikkim Himalaya

M. longifolia Wall.	Sikkim, Himalaya, Assam, and the Khasia Hills
M. magnifica Hood. f.	Western Ghats, parts of Tinnevelly, and
M. malabarica Lamk.	S. Karnataka
M. prainii King	Andaman Islands.
Gymnacranthera canarica Warb	Karnataka, Kerala.
Knema attenuate Warb.	Western Ghats
K. andamanica spp. *nicobarica* *K. andamanica* spp. *andamanica*	Nicobar, Andaman Islands.

Table 7. High yielding accession of nutmeg

Category	**Accession**	**Remarks**
Essential oil in nutmeg	A9-18	16.5%
Essential oil in mace	A9-18	26.1%
Butter	A11-12	44%
Oleoresin in nutmeg	A9-30 A9-116	5.3%(acetone extract) 23% (ethanol extract)
Oleoresin in mace	A4-22	32.2% (acetone extract)
High myristicin & elemicin in nutmeg oil	A4-17, A4-20, A9-4-12, A9-4-13, A9-4-15	
High myristicin & elemicin in mace oil.	A4-17, A9-4-1, A9-4-3, A9-4-8, A9-4-11	
High myristicin in both nutmeg and mace oils.	A4-17	
Low myristicin and	A4-22, A9-69, A9-71,	

elemicin levels in nutmeg oil	A9-95 and A9-102	
Low myristicin and elemicin levels in mace oil.	A9-1, A9-44, A9-71 and A9-95	
Low myristicin, low elemicin and low safrole coupled with high sabinene in both nutmeg and mace oils.	A9-71 and A9-95	

Conservation of germplasm

The germplasm collections of nutmeg at IISR include 484 accessions. The important species conserved at IISR include *M. fragrans*, *M. fatua* var. *magnifica*, *M. malabarica*, *M. beddomeii*, M. *andamanica*, *M. attenuata*, *M. prainii*, *M. amygdalina*, *Gymnacranthera canarica* and *Knema andamanica* (Table 4). The unique types are a tree bearing 1-4 seeds per fruit, an endangered species, M. *fatua* var *magnifica* and few elite lines. Another bold accession A9-69 and a 'bald type' are of importance. The germpalsm is conserved in the field repository at Indian Institute of Spices Reseach Calicut. Germpalsm of nutmeg is also conserved at NBPGR Regional Station, Trissur, Kerala Agricultural College, Tamil Nadu Agricultural College, Konkan Krishi Vigyan peeth, Dapoli, College of Agriculture, Dapoli etc.

Rare/threatened species

Myristica swamps are considered as an endangered habitat. The species *M. magnifica* var *fatua, M. malabarica* and G. canarica are reported to be rare/threatened and need to be conserved. *M. malabarica* has been reported as endangered crop plant (Hammer and Khoshbakht 2005). *M dactyloides* included as red listed species from Charmadi and Kammangundi (Western Ghats) is now found widely distributed in those areas (Aravind *et al.* 2005).

Conclusion

Myristica swamps are considered as an endangered habitat. Conservation of the *Myristica* swamps with their ancient and unique biota, and associated ecological value, is of paramount importance as they are priceless possessions for evolutionary biologist. These swamps are virtually live museum of ancient life of great interest to biologists. The forest department of the respective state, with the help of biologists and conservationists should protect these fragmented swamps for prosperity. The still surviving *Myristica* swamps has to be declared as specially protected areas. A major threat to the Travancore *Myristica* swamps was their conversion into rice fields. It is important to prevent conversion of the swamps into paddy fields and betelnut gardens to protect these swamps.. Since *Myristica* swamps are the most endangered and fascinating habitats/ecosystems, they have good potential for developing ecotourism. If myristica swamps can be associated with sacred groves traditional conservation practices can be adopted.

Clove

The clove of commerce is the dried, aromatic, fully grown but unopened flower buds of *Syzygium aromaticum* (L.) Merr. & Perry (Syn. *Eugenia caryophyllus* (Sprengel) Bullock & Harrison) (Myrtaceae). Clove is indigenous to Moluccas where it occurs as a second storey forest tree on the lower mountain slopes. The Dutch Government had restricted the cultivation of clove exclusively to Moluccas but by 19th century beginning, it was smuggled to Mauritius and later on established in the islands of Zanzibar and Pemba. These islands, now part of Tanzania, have become the world's largest producer of clove followed by Indonesia. Under natural conditions, both aromatic and non-aromatic trees occur and the selective culture of aromatic trees led to the present clove population in the world all over. In India, clove cultivation is limited to parts of Kerala and Kanyakumari, Tirunelveli and the Nilgiris of Tamil Nadu. The clove plantation within our country is reported to have originated from a few seedlings introduced from Mauritius.

Clove belongs to the genus *Syzygium* Gaertn. (Myrtaceae) with about 500 species. Genus *Syzygium* Gaertn. has spread to many tropical countries. Many species of *Syzygium* occur in the Indian sub-continent, but they are all very distant species resembling clove only on taxonomic grounds. Hence, a detailed listing of these species is not attempted here. The important species of *Syzygium* occurring in the Western Ghat forests are *S. aromaticum, S. cuminii, S. fruticosum, S. jambos, S. zeylanicum, S. travancoricum* and *S. jambolana.*

Flowers of clove are hermaphrodite, borne at the terminals in trichotomonous panicles, with 3-20 flowers/panicle. Floral biology of cloves favours self pollination. Self pollination is reported to be more probable mechanism for pollination in clove, as maximum pollen viability and stigma receptivity are attained simultaneously. However, flowers are frequently visited by ants, thrips and bees, suggesting possibility of transferring the pollen from the anther to stigma of same flower or cross pollination.

Genetic base of clove in India is narrow because the original number of introductions was few. Clove tree appears to be uniform type and no distinct varieties/cultivars have been recognized. It is also known that the tree population in Zanzibar and Madagascar are also rather uniform, but in Indonesia, 3 types are distinguished. These types differ in tree habit, leaf size, clove size and colour. In India, differences have been observed in the tree shape, bearing habits, cropping season, yield, colour of the petiole, shape and size of clove.

Seed and seedling characters of progenies of 14 elite clove trees revealed no appreciable variation for 100 fruit weight, 100 seed weight, fruit breadth, fruit length, seed breadth, seed length, germination percentage, root and shoot length and number of leaves of seedlings at 40 days after sowing, one and two years old plant height among the progenies of elite lines at the seedling stage (Krishnamoorthy and Rema, 1994). Morphological variability in seedling characters of the progenies of indigenous accessions was found to be very narrow.

The characteristic odour and flavour properties of clove bud, leaves and stem are determined by the composition of their aromatic steam volatile oils. The odour and flavour characteristic of these three types of oils differ significantly owing to the relative abundance of the minor and trace components present. The major component of the volatile oil is eugenol. In the buds, the aromatic steam volatile oil can be as high as 17 per cent. The oil recovery in stem ranges from 4 to 7 percent and leaf is 0.5 to 3 per cent.

Yield in clove is determined by the age, number of flower buds/inflorescence, number of inflorescence etc. The flowers/inflorescence vary from 3 to 20 and number of inflorescence/shoot from 1-7 in different accessions.

At present, the crop improvement programme in clove is limited to the selection of mother trees based on their regular and heavy bearing nature by surveying clove growing tract, besides selection in germplasm. Recently with the introduction of dwarf gene source in the conservatory, it is proposed to develop a dwarf, bushy and early bearing tree with bold cloves. This would favour easy harvest and other cultural operations. High oil yielding accessions would be beneficial for the distillation of oil. Breeding trees with high leaf oil and bud oil would also be advantageous, but is not easy to achieve these aims due to the lack of wide variability in the population. The only way is to introduce further variability from Zanzibar and Indonesia and then initiate a cross breeding programme. Clonal propagation of selected mother trees, avoiding a juvenile phase may result in a breakthrough in productivity.

Conservation

Surveys were conducted in the major clove growing areas of Tamil Nadu and Kerala and a total of 408 accessions are conserved in the germplasm repository of clove at Indian Institute of Spices Research, Calicut. Special efforts were made to identify and collect diverse types form Ashamboo hills, the southern most hills of India, where clove was first introduced. The distinctly diverse collection of clove includes three morphological variations *viz*., dwarf and bushy types, accession with exceptionally bold and thick clove buds (king clove) and narrow leaved variants (Krishnamoorthy and Rema 1994), whereas a reddish purple petioled Zanzibar type from Zanzibar island and one from Sri Lanka are the only introductions at present. Very rarely clove tree with very small buds called *lilliput* clove is also observed in clove. A dwarf gene source in clove has important breeding value in developing dwarf genotypes with compact canopy size. Some of the impotant species of *Syzygium conserved* at IISR are *S. aromaticum,* S. *heynianum,*S. *jambos,*S. *jambolana,*S. *fruiticosum,*S. *cuminii,*S. *caryophyllatum,*S. *lanceolatum,and* S. *zeylanicum* (Table 4).

Allspice

Allspice, *Pimenta dioica* (L.) Merr. (syn: *P. officinalis* Lindl., *Myrtus pimenta* L. , *M. dioica* L. and *Eugenia pimenta* DC (Merrill 1947) is a polygamodioecious evergreen tree, the dried unripe fruits of which provide the culinary spice, pimento, of commerce. Leaves are aromatic and are used in the distillation. The berries are used for the preparation of essential oil and oleoresin. It belongs to the family *Myrtaceae* and is known in English as allspice or pimento. The family *Myrtaceae* consists of about 3000 woody species, most of which is grown in the tropics. The genus *Pimenta* Lindl. Consists of about 18 species of aromatic shrubs and trees native to tropical America. The genus is closely related to *Myrtus* L. and *Eugenia* L. The commercially important *Pimenta* spp. are *Pimenta dioica* (L.) Merr. providing the spice pimento (allspice) and *P. racemosa* (Mill) Moore, bay or bay rum tree providing oil of bay.
Allspice is a small, functionally dioecious evergreen tree, 7–10 m tall, slender trunk profusely branched at their extremities. Bark, smooth and shiny, pale silvery brown, shedding in strips of 25–75 cm long at intervals. Leaves, borne in clusters at the ends of the branches, simple, opposite, entire, thinly, coriaceous, punctate with pellucid glands, aromatic when crushed. Flowers structurally hermaphrodite, but functionally male or female, white, aromatic, 8–10 mm diameter.

The tree is indigenous to West Indies. Jamaica is the major producer and exporter of the spice. The trees are also found in Central America (Mexico, Honduras, Guatemala, Costa Rica and Cuba) and in the neighbouring Caribbean islands, although it's original home is in dispute.

Allspice was introduced into West Indian Islands (Grenada, Barbados, Trinidad and Puerto Rico) from its place of origin. Attempts to introduce it into countries in tropical regions namely, India, Sri Lanka, Fiji, Malaysia, Singapore and Indonesia (Java, Sumatra) have not succeeded fully due to various reasons. In India, a few trees are available in Maharashtra, Tamil Nadu, Karnataka and Kerala. In India, the plant is reported to be grown in some gardens, especially in Bengal, Bihar and Orissa. There are a few allspice trees available in Nagarcoil, Kallar, Burliar and Horticultrual Research Station, Ambalavayal.

In IISR, Calicut has a germplasm collection of 180 trees. Variants are rarely reported in allspice. Two seedling variant types with dwarf/semi-dwarf habit and short internodes and bushy nature possessing a large number of branches are being conserved in the field germplasm repository of Indian Institute of Spices Research, Calicut, Kerala, India. The leaves were smaller (about 1/3 the size) when compared to that of normal leaves. The variants were multiplied clonally through approach grafting and all the clones exhibited the parental character at IISR, Calicut. This dwarf/semi-dwarf plant type in allspice with large number of branches offers great potential in utilizing them in crop improvement programmes.

References

1. Babu L. & Krishnamoorthy B. 2002. Biodiversity in cinnamon germplasm -a qualitative evaluation. National Seminar on Strategies for Increasing Production and Export of Spices, Calicut 24-26 October 2002. p.4
2. Bakker M E, Gerritsen A F and Van Der Schaaf P J. 1992 Leaf anatomy of *Cinnamomum* Schaeffer (Lauraceae) with special reference to oil and mucilage cells. Blumea, 37, 1-30.
3. Baruah A, Nath S C, Boissya C L. 2000. Systematics and diversities of *Cinnamomum* species used as Tejpat spice in North-east India. J. Econ. Taxon. Bot. 24 (2): 361– 374.
4. Bradu B L, Sobti S N. 1988. *Cinnamomum tamala* in N. W. Himalayas; evaluation of various chemical types for perfumery value. Indian Perfumer 32 (4): 334 – 340.
5. Corner F J H. 1976. The Seeds of Dicotyledons. Cambridge Univ. Press, Cambridge.
6. Fujita Y. 1967. Classification and phylogeny of the genus *Cinnamomum* in relation to the constituent essential oils. Bot. Mag. Tokyo, 80, 261-271.
7. Gawankar M.S. Shingre D.V and Jamadagni B. M. 2001. Variability for morphological properties of fruits in Kokum. ABSTRACTS, National Seminar on Kokum, May 12-13, Regional Fruit Research Station Vengurla, Maharashtra, p-2.
8. Gulati B C. 1979. Proc. Symp. Production and utilization of Forest Products, RRL, Jammu, Vol 1, 130 – 139.
9. Haldankar P M. Joshi G D, Patil B P and Haldavnekar P C. 2004. Variability for growth, flowering and fruit set in seedling progenies of nutmeg (*Myristica fragrans* Houtt.) Journal of Spices Aromatic Crops 13 (1): 28-33.
10. Hammer K and Khoshbakht K 2005. Towards a red list for crop plant species. Genetic resources and crop evolution. 52: 249-65.
11. Hooker J D. 1872. Flora of British India, Vol. 1. Dehra Dun, International Book Distributors.
12. Hussain A, Virmani O P, Sharma A, Kumar A, Misra LN. 1988. Major Essential Oil Bearing Plants of India. Central Institute of Medicinal Plants, Lucknow. pp. 213 – 214.
13. Joy P P, Thomas J, Mathew S and Ibrahimm K K. 1998. Growth leaf oil yield and quality investigations in Cinnamon (*Cinnamomum verum*) J. Med. Aromatic Plants 28, 401-406
14. Karnik AR, Raorane GP and Bhagwat N R 2001. Flower types biology and sex forms in kokum (*Garcinia indica* Chiosy) (Abstract). National Seminar on Kokum, May 12-13, Regional Fruit Research Station Vengurla, Maharashtra p.3
15. Kostermans A J G H. 1983. South Indian species of *Cinnamomum* Schaeffer (Lauraceae). Bulletin of the Botanical Survey of India. 25 (14): 90 –133.

16. Krishnamoorthy B and Rema J. 1994. Characterization of seedling progenies of elite lines of clove. Indian Cocoa Arecanut and Spices J. 18(3): 82-84.
17. Krishnamoorthy B and Rema J. 1994. Three promising morphological variants in clove (*Syzygium aromaticum*) (L.) Merr. & Perry) from Tamil Nadu, India. Journal of Spices and Aromaticum Crops 3(2): 168-169.
18. Krishnamoorthy B, Gopalam A and Jose Abraham. 1988. Quality parameters of *cinnamom* (*Cinnamomum verum*) in relation to flush colour. Indian Cocoa Arecanut and Spices., 12(2): 38.
19. Krishnamoorthy B, Rema J and Sasikumar B. 1991. Progeny analysis in cinnamon. Indian Cocoa, Arecanut & Spices J. 14(3): 124-125.
20. Krishnamoorthy B, Sasikumar B, and Rema, J. 1996. Genetic variability and segregation of sex in nutmeg *(Myristica fragrans Houtt.)*. Journal of Plantation Crops 24 (Suppl.): 468-472.
21. Krishnamoorthy B, Sasikumar B, Rema J and Gopalam A. 1992. Variability and association studies in cinnamom (*Cinnamomum verum*). J. Spices and Aromatic Crop, 1(2): 148-150.
22. Krishnamoorthy B, Sasikumar B, Rema J, Sayed A A M and Jose Abraham 1991. Variability and association in nutmeg. Indian cocoa, Arecanut & Spices J. 14(3): 121-122.
23. Krishnamoorthy K 1960. In: Tropical Moist Evergreen Forest Symposium, Forest Research Institute Dehra Dun
24. Krishnamoorthy, B, John Zachariah T. Rema J, and Mathew P A. 1999. Evaluation of selected Chinese cassia *(Cinnamomum cassia)* accessions for chemical quality. Journal of Spices and Aromatic Crops 8 (2): 193-195.
25. Manilal K S and Shylaja M. 1986. A new species of *Cinnamomum* Schaeffer (Lauraceae) from Malabar. Bull. Bot. Survey India, 28: 111-113.
26. Maya K M, John Zachariah T and Krishnamoorthy B. 2004. Chemical composition of essential oil of nutmeg (*Myristica fragrans* Houtt.) accessions. J. Spices Aromatic Crops 13 (2): 135-139.
27. Nath S C, Baruah A, Hazarika A K. 1999. Essential oils of leaves of *Cinnamomum* Schaeffer members. Indian Perfumer 43(4): 182 –190.
28. Nath S C, Hazarika A K, Singh R S. 1994. Essential oil of leaves of *Cinnamomum tamala* Nees. & Eberm. from North East India. J. Spices and Aromatic Crops 3(1): 33 – 35.
29. Nigam M C, Ahmed A. 1990. The essential oil of *Cinnamomum tamala* II PAFAI, 12 (3): 24 – 35.
30. Parthasarathy, V A, Utpala, P and Kumar, A. 2008. Spice Crops Vol.2. Tree Spices-.Today and Tomorrow Printers and Publishers (India) p. 371.

31. Ranatunga J, Senanayake U M. and Wijesekera R O B. 2004. Cultivation and management of Cinnamon. In: Ravindran P N, Babu K N and Shylaja M. 2004. Cinnamon and Cassia The genus *Cinnamomum* CRC Press, Washington D. C.
32. Ravindran S, Krishnaswamy N R, Manilal K S and Ravindran P N. 1992. Chemotaxonomy of *Cinnamomum* Schaeffer occurring in Western *Ghats J. Indian Bot. Soc., 71, 37-41.*
33. Ravindran P N, Babu K N and Shylaja M. 2004. Cinnamon and Cassia The genus *Cinnamomum* CRC Press, Washington D. C.
34. Shinde A K, Godse, SK, Dalvi, MB, Bhole S R and Patil B.P. 2001. Survey of kokum seedling for elite type from Sindhudurg District. (Abstract) National Seminar on Kokum, May 12-13, Regional Fruit Research Station Vengurla, Maharashtra P.5.
35. Shylaja M. 1984. Studies on Indian *Cinnamomum.* Ph. D thesis, University of Calicut
36. Sood R P, Padha C D, Talwar Y P, Jamwal R K, Rao PR. 1979. Essential oil from the leaves of *Cinnamomum tamala* Nees et Eberm. Growing in Himachal Pradesh. Indian Perfumer. 23: 75 – 789.

Organic farming in spices: Prospects and challenges

C.K.Thankamani
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Introduction

India is the major producer, consumer and exporter of spices in the World, growing about 60 different varieties of spices and produces about 70.75 lakh MT of spices, from 35.3 lakh hectares. Since organic foods are free from chemical contaminants, the demand for these products is steadily increasing. Organic farming is a production system which avoids the use of chemical fertilizers, pesticides, chemical growth regulator and is based on use of natural on farm organic inputs, with minimal use of permissible minerals. In these method varieties that are resistant or tolerant to diseases, pests and nematode infection should be used. All crop residues and farm waste available on the farm is to be recycled so that soil fertility is maintained at high level. Weeding is to be limited to slashing as far as possible. Mulching should be practiced with slashed materials and ground should be covered with green manure crops. Prophylactic measures should be taken to prevent diseases. No chemical pesticides or fungicides may be applied. However, Bordeaux mixture for fungus disease control is generally allowed. The organic farming does not aim only at higher crop yield or returns but also developing long term self-sustainable practices. With the demand for organic foods, the demand for spices and spice products are also steadily increasing. Organic cultivation practices of black pepper,ginger,turmeric and major challenges in cultivation are described below.

Components of organic farming

Essential components of organic farming are keeping the soil alive through effective management of natural resources. They are as follows

- **Enrichment of soil:** Abandon use of chemicals, use crop residue as mulch, use organic and biological fertilizers, adopt crop rotation and multiple cropping, avoid excessive tilling and keep soil covered with green cover or biological mulch.
- **Management of temperature:** Keep soil covered, plant trees and bushes on bund
- **Conservation of soil and ran water:** Dig percolation tanks, maintain contour bunds in sloppy land & adopt contour row cultivation, dig farm ponds, maintain low height plantation on bunds.
- **Harvesting of sun energy:** Maintain green stand throughout the year through combination of different crops and plantation schedules.
- **Self-reliance in inputs:** Develop your own seed, on-farm production of compost, vermicompost, vermiwash, liquid manures and botanical extracts.
- **Maintenance of life forms:** Develop habitat for sustenance of life forms, never use pesticides and create enough diversity.
- **Integration of animals:** Animals are important components of organic management and not only provide animal products but also provide enough dung and urine for use in soil.
- **Use of renewable energy:** Use solar energy, bio-gas and other eco-friendly machines.

Organic black pepper

India is one of the leading producer, consumer and exporter of black pepper in the World. Black pepper is cultivated to a large extent in Kerala and Karnataka and to a limited extent in Tamil Nadu and North Eastern states. When pepper is grown in a mixed cultivation system, it is essential that all the crops in the field are also subjected to organic methods of production. An isolation belt of at least 25 m wide is to be left from all around the conventional plantation. Any produce grown on this isolation belt cannot be treated as organic. Precautions should be taken to avoid the entry of runoff water and chemical drift from neighboring farms, if they are not organically cultivated. For an existing plantation, a minimum of three years is required as conversion period where as for a newly planted or replanted area the first yield itself can be considered as organic produce provided chemicals have not been used in the previous cropping. Mulching should be practiced with slashed materials and ground should be covered with green manure crops. For new planting, varieties that are resistant or tolerant to diseases, pests and nematode infection should be used. All crop residues and farm waste available on the farm is to be recycled so that soil fertility is maintained at high level.

Manuring

For nutritional management under organic farming, a judicious application of a combination of organic manures such as farmyard manure @ 5 kg/vine, neemcake @ 1 kg/vine and vermicompost @ 1 kg/vine per year can be made during May-June from 3rd year onwards. FYM can be increased to 10 kg/vine from third yielding year onwards. Biofertilizers such as *Phosphobacteria* and *Azotobactor* can also be applied @ 50 g/vine mixed with farmyard manure. All these mainly provide the nitrogen sources depending upon soil test results. The requirement of potassium can be substituted as ash (0.5-1 kg) or with natural Sulphate of Potash, SOP (100-250gm per vine). In acidic soil it is desirable to apply lime or dolomite at the rate of 500 g/vine in April-May with receipt of pre monsoon showers in alternate years.

To eliminate the deficiency of Mg, Zn, B etc in high yielding plantations IISR has developed foliar micronutrient mixture to be sprayed @ 5gm per litre water in May- June and September-October for getting 15 to 25% extra yield

Disease management

The major disease of pepper is foot rot caused by the fungus *Phytophthora capsici.* The minor diseases are Pollu disease caused by *Colletotrichum gloeosporioides,* stunted disease and slow decline. For the control of foot rot disease, regular adoption of phytosanitary measures is most important. Tillage operations are to be kept to the minimum to avoid soil disturbance and root damage. Proper drainage is essential. Application of *Trichoderma* multiplied in a suitable carrier medium @ 500 g/vine/year is also recommended. Whenever pollu disease or aerial symptoms of foot rot is noticed, restricted spraying of Bordeaux mixture 1 % may be done. Application of crushed neem seed @ 1kg per vine or biocontrol agents like *Pochonia chlamydosporia* @ 50 g/vine in suitable carrier media like FYM or vermicompost twice a year (during April-May and September-October) is suitable to control slow decline/ nematode problems . Pollu beetle (*Longitarsus nigripennis)* may be managed by 0.6% Neemgold (neem product) spray given at 2-

3 week intervals. Clipping of severely infected branches and spraying Neemgold 0.6% and fish oil rosin 3% were also promising against scale insect.

Harvest and post harvest operations
In India, pepper flowers in May-June. The crop takes about 6-8 months from flowering to harvest. The harvest season extends from November to January in plains and January to March in hills. During harvesting the whole spike is handpicked when one or two berries in the spike turn bright orange red. The berries are separated from the harvested spikes and dried in the sun for 7-8 days, on a clean concrete floor or bamboo mat till they are crisp.. The product is dried to the final moisture content of 10%, packed in polythene lined bags and stored at dried place.

Organic ginger
Ginger is cultivated in most of the states in India. However, Karnataka, Orissa, Assam, Meghalaya, Arunachal Pradesh and Gujarat together contribute 65.0 per cent to the country's total production. Indian ginger has high esteem in the global market because of its characteristic lemon like flavour. Since spices like ginger form part of many of ethnic medicines, the demand for organically produced ginger is also increasing considerably.

Conversion plan
For certified organic production of ginger, at least 18 months the crop should be under organic management i.e. only the second crop of ginger can be sold as organic. The conversion period may be relaxed if the organic farm is being established on a land where chemicals were not previously used, provided sufficient proof of history of the area is available. It is desirable that organic method of production is followed in the entire farm; but in the case of large extent of area, the transition can be done in a phased manner for which a conversion plan has to be prepared. A suitable buffer zone with definite border 20 meter is to be maintained around organic plot to avoid contamination .Proper soil and water conservation measures by making conservation pits in the interspaces of beds across the slope have to be followed to minimize the erosion and runoff. Water stagnation has to be avoided in the low lying fields by taking deep trenches for drainage.

Manuring

All crop residues and farm wastes like green loppings, crop residues, grasses, cow dung slurry, poultry droppings etc. available on the farm can be recycled through composting. No synthetic chemical fertilizers, pesticides or fungicides are allowed under organic system. If the soil having potassium deficiency ash or sulphate of potash may be applied in two splits (45 & 90 DAP) @ 125 kg/ha. Application of PGPR strain of *Bacillus amyloliquifaciens* (GRB 35) is also recommended for growth promotion and disease control. Based on soil test, application of lime/dolomite, rock phosphate and wood ash may be done to get required quantity of phosphorus and potassium supplementation. When the deficient conditions of trace elements become yield limiting, restricted use of foliar application of micronutrient mixture specific to ginger is recommended (dosage @ 5 g/L) twice, 60 and 90 DAP, for higher yield as per the limits of standard setting or certifying organizations.

Manuring schedule for ginger (per ha).

Schedule	**Neem cake**	**Rock phosphate**	**Ash**	**Organic manure**
Basal	2 tons	250 kg	-	30 tons cowdung
After 45 days	-	-	0.5 -1 ton	2 ton vermicompost
After 90 days	-	-	50 kg Sulphate of Potash	2 ton vermicompost

Plant protection

Soft rot is the most destructive disease of ginger which results in total loss of affected clumps. Cultural practices such as selection of well drained soils for planting is important for managing the disease, since stagnation of water predisposes the plant to infection. Soil solarisation before planting may be practiced to kill the pathogen in the soil. Selection of healthy rhizomes, *seed* treatment and soil application of biocontrol agents like *Trichoderma,* PGPR or *Pseudomonas* multiplied in suitable carrier media such as coir pith compost, well rotten cow dung or quality neem cake may be done at the time of sowing and at regular intervals to keep the rhizome rot disease in check. To control bacterial wilt and leaf spot spraying of Bordeaux mixture 1% may be done restricting the quantity to 8 kg copper per hectare per annum. Root knot (*Meloidogyne* spp.), burrowing (*Radopholus similis*) and lesion (*Pratylenchus* spp.) nematodes are major nematode pests of ginger. The nematodes can be controlled by solarising ginger beds before planting /using nematode free seed rhizomes and treating infested rhizomes with hot water (50°C) for 10 minutes,. In areas were root knot nematode population is high, the resistant variety IISR-Mahima may be cultivated. Application of quality neem cake mentioned earlier along with the bioagents *Pochonia chlamydosporia* 20 g/bed at 10^6 cfu/g) the time of sowing will be useful to check the nematode population.

Insect pests

The shoot borer (*Conogethes punctiferalis*) is the most serious pest of ginger and can be managed by spraying neem gold (0.6%) at 21 day intervals during July to October. An integrated strategy involving pruning and destroying freshly infested pseudostems during July-August (at fortnightly intervals) and spraying neem gold during September-October (at monthly intervals) is also effective against the pest. The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages) and in storage. The pest can be managed by treating the seed material with neem based insecticides.

Harvesting

Ginger attains full maturity in 210-240 days after planting The crop is ready for harvest in about 7-8 months after planting when the leaves turn yellow, and start drying up gradually. Irrigation is stopped one month before harvest and the clumps are lifted carefully with a spade or digging fork and the rhizomes are separated from the dried up leaves, roots and adhering soil. For preparing vegetable ginger, harvesting is done from sixth month onwards. The rhizomes are thoroughly washed in water and sun-dried for a day. In large scale cultivations, tractor or power tiller drawn harvesters are used for harvesting the rhizomes.

Organic turmeric

Turmeric (*Curcuma longa*) (Family: Zingiberaceae) is used as condiment, dye, drug and cosmetic in addition to its use in religious ceremonies. India is a leading producer and exporter of turmeric in the world. Andhra Pradesh, Tamil Nadu, Orissa, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra, Assam are some of the important states cultivating turmeric. The share of organic turmeric is only 11 per cent compared to conventional turmeric. Growing demand for natural colours in industry, fast food chains, pharmaceuticals offer a potential scope for organic production of turmeric. Conversion plan criteria and manuring are same as that of ginger.

Plant protection

Use of biopesticides, biocontrol agents, cultural and phytosanitary measures for the management of insect pests and diseases forms the main strategy under organic system. Spraying Neemgold 0.5% or neemoil 0.5% during July-October (at 21 day intervals) is effective against the shoot borer. Selection of healthy rhizomes, soil solarization and incorporation of *Trichoderma,* seed treatment and soil application of biocontrol agents like *Trichoderma* or *Pseudomonas* multiplied in suitable carrier media such as coir pith compost, well rotten cow dung or neem cake may be done at the time of sowing and at regular intervals to control the rhizome rot disease .To control other foliar diseases spraying of Bordeaux mixture 1% may be done. Application of quality neem cake mentioned earlier along with the bioagents *Pochonia chlamydosporia* will be useful to check the nematode population.

Harvesting

Depending upon the variety, the crop becomes ready for harvest in 7-9 months after planting during January-March. Early varieties mature in 7-8 months, medium varieties in 8-9 months and late varieties after 9 months. The land is ploughed and the rhizomes are gathered by hand picking or the clumps are carefully lifted with a spade. The harvested rhizomes are cleared of mud and other extraneous matter adhering to them

Challenges

- Availability of organically produced planting material for cultivation is a major challenge in organic cultivation.
- Climate change, non-availability of farm labourers, irrigation, emergence of new pests and diseases need to be addressed for sustained production of organic spices.

- Adoption of scientific production methods, post-harvest operations are not up to the expectations due to less awareness and also due to market fluctuations.
- Enormous mandatory documentation at the time of inspection , high charges for certification are some other problems
- Constraints to access international markets by individual /group and non-availability of premium prices are some other challenges faced by organic cultivators.

Soil fertility management for enhancing spices productivity

V. Srinivasan

ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

India "Land of Spices" is the World's largest producer, consumer and exporter of spices. Spices were grown in 3.96 million ha with a production of 8.4 million tonnes of which 10.28 lakhs tonnes valued Rs. 17929.55 crores exported in 2017-18. To meet the internal consumption and international demand an annual growth rate of 8 to 10% is envisaged. But Productivity in India is very low comparing to competing countries. Lesser fertilizer inputs, low fertilizer use efficiency and micronutrient deficiency are the major reasons for the low productivity. To manage the problems an integrated plant nutrient management system with technologies for production of 'clean spices' through organic agriculture is developed and discussed below

Soil suitability

Spices though grown in wide variety of soils, well drained virgin red, lateritic and alluvial soils rich in humus are well suitable black pepper. For cardamom deep soils with good drainage having pH from 5 to 6.5 and organic matter 3.2 to 7.8 per cent are well suited. Survey in major cardamom growing areas showed that 68% soils are deficient in zinc, 49% deficient in boron, 28% deficient in Mo and 9% deficient in manganese (Srinivasan *et al*, 1998). That means micronutrient deficiency is one of the limiting factors for cardamom. In India, ginger is grown on sandy loams, clay loams and laterite soil but virgin forest soils that are rich in fertility are ideal. Well drained loamy or alluvial soils with good organic status are well suited for turmeric crop. Being an exhaustive crop, turmeric responds well to judicious application of fertilizers and manures.

Mulching and organic manuring

Growing grass in between pepper vines and mulching with the pruning of the standards enhance the organic matter status and moisture retention capacity. Covering with leaf mulch and terracing conserve soil moisture and fertility and minimize soil loss by erosion as much as by 150%. Studies at IISR showed that growing congo signal grass (*Brachiaria mugiziensis*) with NPK @ 50 kg/ha in the interspace improved soil fertility, reduced aluminum toxicity and nematode population besides increasing pepper yield. Experiments conducted at various locations revealed that inoculation of bio fertilizer *Azospirillum* (50g vine^{-1}) along with 10 kg FYM and 100% recommended inorganic fertilizer dose is ideal

Thick organic mulch in cardamom plantation reduces manganese toxicity in such soils. Coir pith compost having additional urea or FYM or cherry husk compost in 1:1 combination increased the number of suckers and number of panicles

For ginger and turmeric application of green leaf mulch @ 20 t/ha resulted in 200 per cent increase in yield under higher fertility conditions of Wayanad, Kerala. Growing live mulches like green gram, black gram, sesbania, soybean, cowpea and daincha and *in situ* mulching them 45-60 days after planting also resulted in higher yields. Application of neem cake (2 t/ha) or groundnut cake (1t/ha) yielded on par to the application of recommended dose of chemical fertilizers @ 60: 50: 120 kg N, P and K/ha with superior curcumin recovery.

Nutrient Uptake

An adult pepper vine removes 233.4 g N, 16.8 g P, 171.9 g K, 18.3 g Mg, 75.0 g Ca, 365 mg Fe, 281 mg Mn, 104 mg Zn, 89 mg Cu and 60 mg B and the major nutrients must be applied in amounts sufficient to meet the uptake in addition to the allowance made for nutrient losses through leaching. A leaf nutrient concentration of 2.7, 0.1, 3.0, 1.0 and 0.2% of N, P, K, Ca and Mg respectively, are essential for proper growth of pepper and below this they are deficient. The quantities of macro and micronutrients removed through harvesting of produce are directly proportional to the yield. Sucker production in cardamom can be increased by two and half times by application of balanced dose of NPK fertilizers (32.5 g N, 25 g P, 50 g K /plant). The ratio of uptake of NPK, Ca and Mg was 7: 1: 12.3: 2.4: 0.89, respectively. The total uptake by bearing clumps were 26 kg N, 4.4 kg P, 52 kg K, 14 kg Ca and 3.5 kg Mg per hectare. The total K uptake was more followed by N and P in both stages of crop and it suggests that crop requires more of K than N and P. For production of one kg cardamom capsule 0.122 kg N, 0.414 kg P, 0.20 kg K are removed by the plant. Optimum soil fertility level is 60 kg P_2O_5 and 300 kg K_2O /ha for cardamom, as beyond this crop will not show any response.

Studies showed that in ginger uptake of N, P and K in leaf and pseudo stem increase up to 180th day and then decrease, where as that of rhizome uptake steadily increases till the harvest. Ginger rhizomes were mainly N and K exhausting, intermediary in P and Mg removal and the least in Ca removal. A heavy ginger crop removes 35-50 kg P/ha. Higher uptake of K up to third, N up to fourth and P up to fifth months of development was observed with subsequent decrease in their uptake in turmeric. Use of mother rhizomes enhances the uptake of N, P and K as compared to primary or secondary rhizomes for planting. The uptake of nutrients by turmeric is in the order of potassium > nitrogen > magnesium > calcium.

Inorganic fertilizers

The agro-ecological condition, soil nutrient status, soil physical properties, cropping system, disease incidence etc. should be considered while fertilizer applications are made. Studies on phosphatic sources for pepper showed that application of Mussoorie Phos (MRP) @ 80 kg/ha/year was comparable with super phosphate in respect of soil availability, yield response and relative agronomic effectiveness and economics. As a perennial crop, pepper exploits a fixed volume of soil with limited nutrient supply for longer period. Hence, the fertility assessment should be based on the buffering capacity of the soil for long term supply and intensity factor for immediate availability of any nutrient. It has been shown that the additional nutrient requirement for an increase of 1 kg pepper berries is 6.35 N, 6.33 g K, 1.11g Ca, 0.47g Mg, 0.44g P, 0.29g S, 42.82 mg Fe, 34.45 mg Mn and 4.2 mg Zn. Economic analysis of experimental results using appropriate tools enabled identification of risk-free rational technology wherein application of ½ prevailing package of practices + Zn is a risk free rational technology for better returns from black pepper.

Fertilizer requirement of cardamom warrants more liberal application of K whereas N and P are needed in comparatively lesser extents. Significant positive correlation of exchangeable K with cardamom yield was observed. Micronutrient survey conducted by Indian Cardamom Research Institute, Myladumpara, Idukki, Kerala showed that zinc deficiency is widespread in cardamom soils and B deficiency is observed in certain areas. Hence, it is recommended that Zn may be applied as a foliar spray as zinc sulphate at 250 grams 100 liters^{-1} of water during April-May and September-October.

In ginger P application at 20 & 40 kg/ha increased yield by 21.5 & 11.5 per cent respectively. Application of micronutrients Zn, B and Mo @ 5, 2 and 1 kg/ha increased the rhizome yield by 48 per cent over control. In turmeric, the response to applied P is reported up to 175 kg P/ha with the combination of other nutrients. The response to K was varying with increased yield upto 180 kg K_2O per ha. Application of potassic fertilizers in splits (basal, 40, 80 and 120 DAP) responded in terms of higher rhizome yield (30 t/ha) upto the level of 90 kg/ha. Upto 24% increase in rhizome yield with the application of $FeSO_4$ @ 30 kg/ha was observed in Fe deficient soils of Tamil Nadu. Application of $ZnSO_4$ @ 15 kg/ha increased the rhizome yield by 15%. Combined application of 50 kg/ha each of $FeSO_4$ and $ZnSO_4$ recorded an increased yield upto 21.4 t/ha. The optimum dosage of Zn, B and Mo has been formulated as 5, 2 & 1 Kg/ha with 20 and 15 tonnes of FYM and green mulching for sustainable yield in turmeric along with recommended fertilizer. Targeted yield equation for predicting nutrient requirements to get fixed rhizome yields in soils with varying fertility levels was standardized in ginger based on long term field trials. The economic optimum in terms of profitable response for money invested was found to be Rs. 3.75/ bed (3 m^2) for N, Rs. 1.30/ bed for P and Rs. 0.60/bed for K.

ICAR-IISR developed crop and location specific foliar nutrient mixtures suited for black pepper, cardamom, ginger and turmeric crops for varying soil pH conditions. The micronutrient mixture for black pepper has been designed to fulfill the requirement by maintaining optimal leaf nutrient ratio of secondary (Mg) and micronutrients (Zn and B) in the leaf. This crop specific mixture is recommended as a foliar spray and guarantees 10 to 25% increase in yield.

Means to increase fertilizer use efficiency in spices

Spice soils are generally deficient in available P, Ca, and Mg and with low CEC. Intensive survey in spice growing areas of Kerala showed that 57% of the samples collected were low in P and judicious application of P is vital in these soils for sustainable production. Fifty per cent of turmeric growing soils in Andra Pradesh are Zn deficient, more than 80 % are deficient in Fe and 80 % of them are calcareous (with > 50% of $CaCO_3$) and 52% of soil collected from Karnataka and 9% sample collected from Kerala are deficient in K.

Use efficiency of N fertilizers increased with the number of split doses applied and decreased with the rate of application. Application of urea @ 140 Kg N/ha in five split doses along with 60 kg P_2O_5 and 60 kg K_2O recorded higher yield of 22.9 t/ha in turmeric. It was reported that application of 1% neem coated urea @ 50 kg/ha to black pepper increased the yield of pepper by 51% over normal urea application.

As ginger removes a large quantity of K from the soil, up to 500 kg/ha (Asher & Lee, 1975), split application of potassium, in two-three splits at basal, 60 and 120 DAP give greater response than single basal application. Response to micronutrients is prominent when applied as foliar sprays. Increase in yield of cardamom due to foliar application of 500 to 750 ppm zinc was up to 23 per cent. Turmeric shows good response to the application of organics and bio fertilizers. Integrated application of coir compost (2.5 t ha^{-1}) combined with FYM, Azospirillum and half the recommended NPK significantly increased yield and quality of turmeric.

Direct application of phosphate rocks will be agronomically and economically more attractive than the use of expensive water soluble P fertilizers in soils having high P fixing capacity.

Constraints in nutrient management

In India agriculture production leaves an estimated negative nutrient balance of 10.0 M tons per year of NPK which is likely to increase. At an estimated nutrient removal of 37.5 M tons of NPK (11.9 N + 5.3 P_2O_5 + 20.3 K_2O M tons) to meet food production by 2020, the nutrient balance identifies excess use of N and P_2O_5, and deficit use of nearly 18 M tons of K which accounts for 55% of NPK removal. The total fertilizer consumption in India during 2010-11 was 28.12 Mt (16.55 N + 8.05 P_2O_5 + 3.51 K_2O Mt). Under this scenario, the total estimated fertilizer consumption for spices production is only 348.7 thousand tons (hardly 1.2%), of which the major spices that are grown under acid soil environments are applied with 89.54 thousand tons of NPK. But their estimated nutrient removal by the way of harvesting is 134.36 thousand tons, identifying an excess use of P_2O_5 and deficit of N and K_2O to the tune of -14 and -41 thousand tons, respectively (Table 1). The nutrient demand for production of these major spices to achieve the yield goals of 2025 will be 183.15 thousand tons.

Alternative sources to meet nutrient requirements and overcome the constraints:

In India, animal dung in the form of FYM remains the only popular organic input to the land. Country produces nearly 500 million tonnes of FYM yielding a share of 3.5 t/ha when distributed over an area of 145 million ha of cultivated area. Approximately 350-375 million tonnes of crop residues are also produced annually from all field crops and are also substantially supplemented by residue materials from several plantation crops grown. Despite this huge amount of residues from fields and plantation crops, general awareness on the role of plant residues in improving soils productivity is lacking in India and especially in spices. Conjoint use of chemical fertilizers and organic residues would serve as an alternative and resist the emergence of multiple micronutrient deficiencies.

Further, generation of potentially recyclable resources like press mud from sugar factories, animal / human, urban wastes and sewage sledge for use in agriculture as nutrient sources, and systematic evaluation on the feasibility and efficacy of these wastes not only in improving spice and soil productivity and quality but also in promoting the efficiency of inorganic fertilizers specially under spices is warranted.

Future thrust areas

For attaining identified goals, following thrust areas are proposed:

- Characterization, Inventorization and Monitoring of different natural resources of nutrients
- Standardization of the method of composting different organic residues for obtaining uniformly good quality compost or organic product.
- Identifying cheaper and efficient sources of nutrients and low input technologies to alleviate macro and micro nutrient deficiencies in location specific soil-crop systems.
- Rational use of urban and rural wastes, crop residues, green manures, vermi composts and coir composts etc. to augment spice productivity and soil health.
- Investigating the effect of rhizosphere organisms on mobilising the insoluble sources of plant nutrients leading to development of efficient nutrient utilization systems.
- Identifying efficient location specific strains of bio fertilizers and developing IPNS through conjoint use of organics, at least to meet one third to half of the plant nutrient requirement.
- Improving spice crop intensity by developing agro-ecozone specific farming systems.
- Development of "organic/Eco spice concept" – to produce zero defect spice products through organic farming by utilizing plant based products, composts and bio inoculants for sustainable production.

Table 1. Nutrient removal by different spices crops

Crop*	Av. yield (dry) kg/ha	Uptake (kg/ha)								
		N	P_2O_5	K_2O	Ca	Mg	Fe	Mn	Zn	Cu
Pepper	2000	42.0	7.0	40.0	6.4	3.9	0.09	0.10	0.04	0.03
Cardamom	450	6.0	2.1	16.8	3.4	1.2	0.10	0.16	0.03	0.006
Ginger	4800	170.0	30.0	132.0	8.6	9.1	1.8	0.5	0.13	0.04
Turmeric	5300	135.0	43.0	215.0	10.1	16.0	1.2	0.8	0.24	0.05
Clove	275	3.1	1.0	2.8	3.3	0.8	0.01	0.08	0.07	0.002
Nutmeg	750	7.8	1.9	3.7	4.4	1.2	0.21	0.02	0.01	0.01

* nutrient removal based on average economic produce yield only

Diseases of Ginger and Turmeric

R Praveena
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Ginger

Soft rot

Soft rot is the most destructive disease of ginger which results in total loss of affected clumps. The disease is soil-borne and is caused by Pythium spp. among which, *P. aphanidermatum* and *P. myriotylum* are widely distributed in the country. The fungus multiplies with buildup of soil moisture with the onset of south west monsoon. Younger sprouts are most susceptible to the pathogen. The infection starts at the collar region of the pseudostem and progresses upwards as well as downwards. The collar region of the affected pseudostem becomes water-soaked and the rotting spreads to the rhizome resulting in soft rot with characteristic foul smell. At a later stage root infection is also noticed. Foliar symptoms appear as light yellowing of the leaf margins of lower leaves which gradually spreads to the leaf lamina. In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. The yellowing spreads to all leaves of the plant from the lower region upwards and is followed by drooping, withering and drying of pseudostems.

Management

- Rhizome selection: Infected rhizomes are the primary source of infection and spread of the disease in the field. The best method to manage the disease is by the use of apparently good looking and healthy rhizomes which are free of disease for planting.
- Seed treatment: Treat the seed rhizomes for 30 minutes with mancozeb (0.3%) or carbendazim (0.3%) prior to storing and planting. Carbendazim alone or in combination with mancozeb is also used to prevent the seed borne inoculum of the fungi.
- Drainage: One of the predisposing factors for soft rot of ginger is ill drained field in continuous wet weather. Proper drainage in sandy loam soil for cultivation ensures healthy crop of ginger.
- Mulching: Application of mulches is a common practice in rainfed ginger production to conserve soil moisture and weed suppression. Mulching ginger beds with dried leaves at the time of planting reduces the incidence of soft rot.
- Soil solarization: Soil solarization or soil disinfection need to be adopted in disease prone areas by covering moist soil with transparent polyethene film during high temperature and intense solar radiation. This results in the decline of soil borne inoculum and consequently reduction in disease incidence.

- Chemical control: When incidence of rhizome rot is observed, remove the affected clumps and drench the affected and surrounding beds with mancozeb (0.3%) or metalaxyl - mancozeb(0.125%).
- Application of *Trichoderma harzianum* along with neem cake @ 1 kg/bed helps in reducing the incidence of the disease. Biocapsules of *Bacillus amyloliquefaciens* can also be used at the time of planting, 45 and 60 days after planting .The capsules need to be dissolved in water one night before application and the next day the solution can be diluted and used for drenching ginger beds. The prepared biocapsule solution can be used for treating seed rhizomes also.

Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* Biovar-3 is a soil and seedborne disease that occurs during south west monsoon. Water soaked spots appear at the collar region of the pseudostem and progresses upwards and downwards. The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spread upwards. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms. The vascular tissues of the affected pseudostems show dark streaks. The affected pseudostem and rhizome when pressed gently extrudes milky ooze from the vascular strands. Ultimately rhizomes rot emitting a foul smell. It is not advisable to plant ginger consecutively in the same field every year.

The strategies for management of bacterial wilt are:-

- Selection of healthy rhizome material from disease free area.
- Selection of field with no history of bacterial wilt in the past. Fields used for growing potato, or other solanaceous crops are to be avoided.
- Solarization of soil prior to planting of ginger.
- Pre-plant rhizome treatment by heat or rhizome solarization.
- Strict phytosanitation in the field including restrictions on movement of farm workers and irrigation water across the field.
- Clean cultivation and minimum tillage.
- Crop rotation with non-host plants like cereals such as paddy, maize etc.

- Management of Insect pest and nematode in the field.
- Application of soil amendments including biological control agents.
- Once the disease is noticed in the field the affected clumps may be removed carefully without spilling the soil around and the affected area and surrounding areas drenched with copper oxychloride 0.2%. Care should be taken to dispose the removed plants far from the cultivated area or destroyed by burning.

Leaf spot

Leaf spot is caused by *Phyllosticta zingiberi*. The disease starts as water soaked spot and later turns as a white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through rain splashes during intermittent showers. The incidence of the disease is severe in ginger grown under exposed conditions.

Management

- Burning of infected crop debris is an important practice to reduce the primary inoculum of the disease.
- Seed rhizome can be treated with carbendazim + mancozeb combination or carbendazim (0.25%) before planting.
- For managing leaf spot disease Bordeaux mixture (1%), mancozeb (0.3%) or carbendazim (0.1%) may be sprayed at 15 days interval.

Turmeric

Leaf blotch

Leaf blotch is caused by *Taphrina maculans* and appears as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become dirty yellow or dark brown.

The leaves also turn yellow. In severe cases the plants present a scorched appearance and the rhizome yield is reduced.

Management

- Field sanitation.
- Crop rotations to reduce the inoculum build up in soil
- Cutting and burning of diseased leaves would greatly help in preventing the spread of disease.
- All short duration cultivars are found resistant to *Taphrina maculans*.
- Spraying with Bordeaux mixture (1%) or mancozeb (0.2%) at 20 days intervals.

Leaf spot

Leaf spot is caused by *Colletotrichum capsici* and appears as brown spots of various sizes on the upper surface of the young leaves. The spots are irregular in shape and white or grey in the centre. Later, two or more spots may coalesce and form an irregular patch covering almost the whole leaf. The affected leaves eventually dry up. The rhizomes do not develop well.

Management

- Select rhizomes from disease free area
- Treat seed rhizomes in 0.3% copper oxy chloride solution.
- Fertilizer application showed definite influence on the disease incidence.
- Excessive shade and mixed cropping with vulnerable hosts should be strictly avoided.
- In field three foliar sprays from first month at 15 days intervals with mancozeb (0.2%) or Bordeaux mixture (1%).

Leaf blight

Leaf blight is caused by *Rhizoctonia solani*. The disease is characterized by the appearance of necrotic patches with papery white centre of varying sizes on the lamina which spread on the whole surface leaving a blighted appearance. The disease occurs during the post monsoon season. The disease can be controlled by spraying Bavistin 0.2% or Bordeaux mixture 1% with the initiation of infection.

Rhizome rot

The disease is caused by *Pythium aphanidermatum*. The lower leaves of the infected pseudostem show yellowing, collar region of the pseudo stem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes.

Management

- Select sites with light soil, the proper drainage facility for growing Turmeric.
- In endemic areas rotation of crops for 3-5 years using non host crops.
- Select seed rhizomes from disease free areas.
- Treat seed rhizome with mancozeb @ 3g per litre of water or Bavistin @ 1g per litre of water. Seed material should be dipped for 30 minutes in the fungicidal solution and should be shade dried before sowing.
- When incidence of rhizome rot is not there in field, dig out the effected plants and drench the field with metalaxyl -mancozeb (0.125%) or copper oxy chloride (0.25%) .
- After the harvested crop seed rhizomes are selected, stored and observed periodically for the incidence of rotting.

Insect pests of spice crops and their management

C. M. Senthil Kumar

ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Introduction

Spices are low volume, high value crops, which fetch high income to the farmers. However, they are ravaged by a variety of pests which cause huge economic damage to the crop. Proper understanding about the pests and timely application of control measures can help to contain the pests without causing serious losses to the farmers. In this chapter, different pests which cause damage to important spice crops such as ginger, turmeric, black pepper and cardamom are listed and their management is discussed.

Pests of ginger

Shoot borer

Shoot borer (*Conogethes punctiferalis*) is the most serious insect pest of ginger. The larvae bore into pseudostems and feed on internal tissues resulting in yellowing and drying of leaves of infested pseudostems. The presence of a bore-hole on the pseudostem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation. The adult is a medium sized moth with a wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs. The pest population is higher in the field during September-October. The shoot borer can be managed by chlorantraniliprole 0.01% or flubendiamide 0.02% or spinosad 0.0225% at 15 days intervals during July to October. The spraying is to be initiated when the first symptom of pest attack is seen on the top most leaf in the form of feeding marks on the margins on the pseudostem. An integrated strategy involving pruning and destroying freshly infested pseudostems during July-August (at fortnightly intervals) and spraying chemicals during September-October (at monthly intervals) is also effective against the pest.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages) and in storage. Adult (female) scales are circular (about 1 mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shriveled and desiccated affecting its germination. The rhizome scale can be managed by timely harvest, discarding severely infested rhizomes, and treating the seed rhizomes with quinalphos (0.075%) (for 20-30 minutes) before storage and also before sowing in case the infestation persists. The seed rhizome may be stored in sawdust + Strychnos nuxvomica leaves (dried) after seed treatment.

Minor pests

Larvae of leaf roller (*Udaspes folus*) cut and fold leaves and feed from within, and are generally seen during the monsoon season. The adults are medium sized butterflies with brownish black wings with white spots; the larvae are dark green. The control measures undertaken against the shoot borer is adequate for the management of the pest. Root grubs (Holotrichia spp.) occasionally feed on tender rhizomes, roots and base of pseudostems causing yellowing and wilting of shoots. The pest can be controlled by drenching the soil around the rhizomes with chloropyriphos (0.075%).

Pests of turmeric

Shoot borer

The shoot borer (*Conogethes punctiferalis*) is the most serious pest of turmeric. The larvae bore into pseudo stems and feed on internal tissues. The presence of a bore-hole on the pseudo stem 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 wingspan of about 20 mm; the wings are orange-yellow with minute black spots. Fully-grown larvae are light brown with sparse hairs. The pest can be managed by spraying chlorantraniliprole 0.01% or flubendiamide 0.02% or spinosad 0.0225% or lamda-cyhalothrin (0.0125%) at 15 days intervals during July to October. Spraying should commence with the appearance of first symptom of pest attack.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes in the field (at later stages of the crop) and in storage. Adult (female) scales are circular (about 1mm diameter) and light brown to grey and appear as encrustations on the rhizomes. They feed on sap and when the rhizomes are severely infested, they become shrivelled and desiccated affecting its germination. To manage the pest, adapt timely harvest of rhizomes. Severely infested rhizomes should be discarded before storage If the infestation persists, treat seed material with quinalphos (0.075%) (for 20-30 minutes) before storage and also before sowing. Store rhizomes in sawdust along with dried leaves of *Strychnos nuxvomica*

Minor pests

Adults and larvae of leaf feeding beetles such as Lema spp. feed on leaves especially during the monsoon season and form elongated parallel feeding marks on them. Control measures undertaken for the management of shoot borer is sufficient to manage this pest. The lacewing bug (*Stephanitis typicus*) infests the foliage causing them to turn pale and dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country. The turmeric thrips (*Panchaetothrips indicus*) infests the leaves causing them to roll, turn pale and gradually dry up. The pest infestation is more common during the post monsoon period especially in drier regions of the country. Spraying any systemic insecticide is effective for the management of the pest.

Pests of black pepper

Pollu beetle

Pollu beetle (*Lanka ramakrishnai*) is the most destructive pest of black pepper and is more serious in plains and at altitudes below 300 m. The adult is a small black beetle measuring about 2.5 mm × 1.5 mm, the head and thorax being yellowish brown and the fore wings (elytra) black. Fully-grown grubs are creamy-white and measure about 5 mm in length. The adult beetles feed and damage tender leaves and spikes. The females lay eggs on tender spikes and berries. The grubs bore into and feed on the internal tissues and the infested spikes turn black and decay. The infested berries also turn black and crumble when pressed. The pest infestation is more serious in shaded areas in the plantation. The pest population is higher during September-October in the field. Shade regulation in the plantation reduces the population of the pest in the field. Spraying quinalphos (0.05%) during June-July and September-October or quinalphos (0.05%) during July and Neemgold (0.6%) (neem-based insecticide) during August, September and October is effective for the management of the pest. The underside of leaves (where adults are generally seen) and spikes are to be sprayed thoroughly.

Top shoot borer

The top shoot borer (*Cydia hemidoxa*) is a serious pest in younger plantations in all black pepper areas. The adult is a tiny moth with a wing span of 10-15 mm with crimson and yellow fore-wings and grey hind wings. The larvae bore into tender terminal shoots and feed on internal tissues resulting in blackening and decaying of affected shoots. Fully grown larvae are greyish green and measure 12-15 mm in length. When successive new shoots are attacked, the growth of the vine is affected. The pest infestation is higher during July to October when numerous succulent shoots are available in the vines. Spraying quinalphos (0.05%) on tender terminal shoots at monthly intervals (during July-October) helps to protect the emerging new shoots.

Leaf gall thrips

Infestation by leaf gall thrips (*Liothrips karnyi*) is more serious at higher altitudes especially in younger vines and also in nurseries in the plains. The adults are black and measure 2.5 mm-3.0 mm in length. The larvae and pupae are creamy white. The feeding activity of thrips on leaves causes the leaf margins to curl downwards and inwards resulting in the formation of marginal leaf galls. Later the infested leaves become crinkled and malformed. In severe cases of infestation, the growth of younger vines and cuttings in the nursery is affected. Spraying systemic insecticides during the emergence of new flushes in the field and cuttings in the nursery will help to control the pest.

Scale insects

Among the various scale insects recorded on black pepper, mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) causes serious damage to black pepper vines at higher altitudes and also to older cuttings in nurseries in the plains. Females of mussel scales are elongated (about 1 mm length) and dark brown and that of coconut scales circular (about 1 mm in diameter) and yellowish brown. Scale insects are sedentary and remain permanently fixed to plant parts and appear as encrustations on stems, leaves and berries. They feed on plant sap and cause yellowing and wilting of infested portions; in severe cases of infestation the affected portions of vines dry up. The pest infestation is more severe during the post monsoon and summer periods. Clip off and destroy severely infested branches. Spraying systemic insecticides on affected vines after harvest of the produce at 21 days interval will be effective to control the pest. Initiate control measures during early stages of pest infestation. In nurseries spraying neem oil 0.3% or Neemgold 0.3% or fish oil rosin 3% is also effective in controlling the pest infestation.

Minor pests

Leaf feeding caterpillars, especially Synegia sp., damage leaves and spikes of younger vines and can be controlled by spraying quinalphos (0.05%). Mealybugs, gall midges and aphids infest tender shoots especially in nurseries. Spraying dimethoate (0.05%) may be undertaken if infestations are severe. Mealybug infestation on roots can be controlled by drenching with chlorphyriphos (0.075%). Undertaking control measures against Phytophthora and nematode infections is necessary in case of mealybug attack.

Pests of cardamom

Cardamom thrips (*Sciothrips cardamomi*)

Cardamom thrips is the most destructive and persistent pest of cardamom, found in almost all the cardamom growing areas. Thrips breed inside the unopened leaf spindles, leaf sheaths, flower bracts and flower tubes. Adults as well as the larvae lacerate and feed on leaves, shoots, inflorescences and capsules. Infestation on the panicles results in shedding of flowers and immature capsules. Feeding activity on tender capsules leads to the formation of corky, scab-like encrustations. The extent of damage may be as high as 80% in certain areas. Population of thrips is generally high during the summer months (February- May) and declines with the onset of monsoon. The Mysore and Vazhukka types are highly susceptible to thrips infestation. The pest can be managed by the following proper shade regulation in the plantation by pruning branches of shade trees and by trashing cardamom plants thrice a year i.e., during early monsoon, mid-monsoon and late monsoon periods to remove breeding sites of the pests. In case of severe infestation, spray insecticides like quinalphos (0.025%), during March, April, May, August and September. Under Karnataka conditions, spraying of fipronil (0.005%) or spinosad (0.0135%)

during February-March, March-April, April-May, September and October is also effective. Avoid spraying operations during peak periods of honey bee activity.

Shoot and capsule borer (*Conogethes punctiferalis*)

The shoot and capsule borer is a serious pest in nurseries as well as in plantations. The larvae bore into pseudostems and feed on the internal contents leading to the formation of ‘dead heart’ symptom. When panicles are attacked, the portion ahead of point of entry dries off. The larvae also bore into the capsules and feed on the seeds resulting in empty capsules. The pest is prevalent throughout the year but higher incidence is pronounced during January-February, May-June, and September-October. To manage the pest, remove infested suckers as indicated by extrusion of frass, during September-October when the infestation is less than 10%. Spraying quinalphos (0.075%) twice, during February-March and September-October coinciding with emergence of panicles and new shoots will help to control the pest.

Root grub (*Basilepta fulvicorne*)

Root grubs are major pests of cardamom in nurseries and main fields. The grubs damage the roots and rhizomes by feeding, sometimes resulting in the death of entire root system. As a result, the plants turn yellow and remain stunted and severely infested plants die. The peak periods of adult emergence are during April and September. Grubs have two periods of occurrence, first during April-July and January. The pest can be managed by collecting and destroying adult beetles during peak periods of emergence i.e. April-May and September-October or by drenching chlorpyriphos (0.075%) twice a year during May-June and August-September synchronizing with emergence of adults and egg laying periods of the pest. Raking of soil before the insecticide application is essential for effective control of root grubs.

Minor pests

Capsule borers

The caterpillars bore and feed on flowers and capsules. The affected capsule become empty, decay and ultimately drops off. The pest is generally serious during the monsoon period. The pest can be managed by regulating shade in thickly shaded areas and by spraying insecticides like quinalphos (0.025%) during March, April, May, August and September.

Hairy caterpillars

Hairy caterpillars appear sporadically in large numbers and cause severe damage to cardamom by defoliating the plants. The caterpillars are gregarious in habit and congregate on trunks of shade trees during the daytime. During early stages of the life cycle, they feed on shade trees and become a pest of cardamom during the later stages. Swarms of hairy caterpillars congregating on the trunk of shade trees during daytime should be collected and killed mechanically. The adults of hairy caterpillars can be captured and killed by operating light traps at night. Spraying contact insecticide like quinalphos (0.05%) will be useful to control the larval stages.

Shoot fly

The larvae of shoot fly feed on the growing shoot of young cardamom plants resulting in formation of dead hearts. The pest incidence is generally severe during October-November and March-April. In general, young plants in the new plantations, which are grown under inadequate shade conditions, are severely affected. The affected shoots should be removed at ground level and destroyed. Spraying quinalphos (0.05%) was found to be effective in managing this pest.

Spices: secondary metabolites and medicinal properties

Anees K and T. John Zachariah
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Spices and aromatic herbs have been used since antiquity as preservatives, colorants, and flavor enhancers. Spices, which have long been the basis of traditional medicine in many countries, have also been the subject of study, particularly by the chemical, pharmaceutical, and food industries, because of their potential use for improving health. Both in vitro and in vivo studies have demonstrated how these substances act as antioxidants, digestive stimulants, and hypolipidemics and show antibacterial, anti-inflammatory, antiviral, and anti-cancer genic activities. Secondary metabolites of spices have occupied great importance as functional foods.

Secondary metabolites(SM) are compounds that are not necessary for a cell (Organism) to live, but play a role in the interaction of the cell (organism) with its environment. These compounds are often involved in plants' protection against biotic or abiotic stresses. Primary metabolism perform essential metabolic role by participating in nutrition and reproduction. Few SMS are used as drugs, flavours, fragrances, insecticides and dyes.

Plants posses' capacity to synthesize different organic molecules called secondary metabolites. They play signaling functions through which influence activities of other cells, control their metabolic activities and coordinates development of whole plant. Plants use secondary metabolites (such as volatile essential oils and colored flavonoids or tetraterpenes) also to attract insects for pollination for seed dispersion. Compounds belonging to terpenoids, alkaloids and flavonoids are being used as drugs or as dietary supplements to cure or as prophylactic for different ailments. Use of stimulants (caffeine, nicotine, ephedrine) fragrances (several essential oils) natural dyes, poisons, hallucinogens (morphine cocaine) etc are based on secondary metabolites. Secondary metabolites are mainly responsible for plant defense and have no direct involvement in the growth and development of such plants. Terpenes, alkaloids and phenolics are three main classes of secondary metabolites in plants which can further be classified into three chemically distinct group's viz. terpenes, phenolics, N (nitrogen) and S (sulphur) containing compounds.

Black pepper

The therapeutic properties of black pepper oil include analgesic, antiseptic, antispasmodic, antitoxic, aphrodisiac, diaphoretic, digestive, diuretic, febrifuge, laxative, rubefacient and tonic (especially of the spleen).

Antioxidant activity

As a natural medicinal agent, black pepper in tea form has been credited for relieving arthritis, nausea, fever, migraine headaches, poor digestion, strep throat, and even coma. It has also been used for non-medical applications as an insecticide. Black pepper or the active principle of black pepper, piperine, can reduce high-fat diet induced oxidative stress. Pepper and pepper containing preparations are used for the treatment of intermittent fever, neuritis, cold, pains and diseases of throat. In Chinese system of medicine pepper is used for the treatment of malaria. IISR Kozhikode India illustrated *in vitro* antioxidant activity and cytotoxicity of four important piper species (*P. nigrum L, P. Chaba Hunter, P. longum L* and P. *Colubrinum* Link)and six black pepper high yielding varieties. . Black pepper (*Piper nigrum* L.) is an important healthy food owing to its antioxidant, antimicrobial potential and gastro-protectivemodules. Black pepper, with piperine as an active ingredient, holds rich phytochemistry that also includes volatile oil, oleoresins, and alkaloids.

More recently, cell-culture studies and animal modeling predicted the role of black pepper against number of maladies. The free-radical scavenging activity of black pepper and its active ingredients might be helpful in chemoprevention and controlling progression of tumor growth. Additionally, the key alkaloid components of *Piper nigrum*, that is, piperine assist in cognitive brain functioning, boost nutrient's absorption and improve gastrointestinal functionality. Black pepper and its active ingredients can be supportive in treating various disorders related to nervous systems that include depression, Alzheimer, epilepsy, etc. The anticancer perspectives of black pepper include modulation of phase-I, phase-II detoxification systems, inhibition of lipid peroxidation, and indeed improvement in antioxidant status .

Among the black pepper varieties, methanol extract of IISR Malabar excel followed by that of Panchami and among piper species chloroform extract of P. *Colubrinum* expressed highest antioxidant activity. They found significant positive correlation between total phenol and antioxidant activity for methanol and chloroform extracts. They also found that chloroform extract of P. *longum* and P. *Colubrinum* and cultivar Malabar excel black pepper showed maximum cytotoxicity against Caski cervical cancer cell lines.

Bio-enhancing ability

Piperine (1-Piperoyl piperidine) is shown to possess bioavailability-enhancing activity with various structurally and therapeutically diverse drugs. Piperine's bioavailability-enhancing property may be attributed to increased absorption, which may be due to alteration in membrane lipid dynamics and change in the conformation of enzymes in the intestine. Ultra-structural studies with piperine showed an increase in microvilli length with a prominent increase in free ribosomes and ribosomes on the endoplasmic reticulum in enterocytes, suggesting that synthesis or turnover of cytoskeletal components or membrane proteins may be involved in the observed effect. In conclusion, it is suggested that piperine may be inducing alterations in membrane dynamics and permeation characteristics, along with induction in the synthesis of proteins associated with cytoskeletal function, resulting in an increase in the small intestine absorptive surface, thus assisting efficient permeation through the epithelial barrier. More recently, cell-culture studies and animal modeling predicted the role of black pepper against number of maladies. The free-radical scavenging activity of black pepper and its active ingredients might be helpful in chemoprevention and controlling progression of tumor growth. Additionally, the key alkaloid components of *Piper nigrum*, that is, piperine assist in cognitive brain functioning, boost nutrient's absorption and improve gastrointestinal functionality. Black pepper and its active ingredients can be supportive in treating various disorders related to nervous systems that include depression, Alzheimer, epilepsy, etc. The anticancer perspectives of black pepper include modulation of phase-I, phase-II detoxification systems, inhibition of lipid peroxidation, and indeed improvement in antioxidants status.

Cardamom

Cardamom essential oil has traditionally been used as a tonic to the digestive system, as well as a component of many sensual aphrodisiac blends. The oil has the aroma of freshly dried cardamom pods, far superior to the comparatively flat steam distilled variety of this oil. Cardamom oil may relieve spasm, making it possibly beneficial for colitis, irritable bowel syndrome, indigestion and cramps. Cardamom oil may be of benefit where the digestive system is affected by nervous tension. In addition, cardamom oil can relieve nausea and may be useful for morning sickness in pregnancy.

Cardamom is strongly tonic and stimulant, stomachic and carminative and to a lesser degree, listed as neuro muscular antisparomatic. It is also reported as anti-inflammatory and analgesic (Al-Zuhair *et al.*, 1996) and is also effective against post-operative nausea and vomiting. The major medicinal properties of cardamom essential oil include the following: Antiseptic, carminative, digestive, diuretic, stimulant, stomachic, tonic, anti-Spasmodic,anti-inflammatory and Antimicrobial.

Antioxidant effect

The essential oil of cardamom is used for its uplifting and invigorating properties and helps digestion and nausea. It is used as an aphrodisiac, helpful in countering the irritation experienced during premenstrual tension (PMS) and works well on the respiratory system, to ease coughs and warming the body.

Ginger

Anti cancer properties

Ginger a natural dietary component has been known to have anti oxidant and anti carcinogenic properties. Studies demonstrated the chemopreventive efficacy of ginger, in colon cancer. In colon carcinogenesis in male Wistar rats, the number of tumors as well as the incidence of cancer was significantly decreased on treatment with ginger. Reports attributed the anti-cancer properties to the presence of pungent vallinoids viz. [6]-gingerol and [6]-paradol, shogaols, zingerone etc. Choudhury et al (2010) shown that the aqueous extract of ginger (GAE) interacts directly with cellular icrotubules and disrupts its structure and induces apoptosis of cancer cells as well. Both the structural and functional properties of tubulin and microtubule were lost, as confirmed by both ex vivo and in vitroexperiments. The major component of GAE is poly-phenols (around 2.5%), which consist of 80% flavones and flavonols. Poly-phenolic compounds are well known to have anti-mitotic properties, and may be further screened for the development of a potential anti-cancer agent.

Anti-inflammatory effect

Ginger contains pungent phenolic substances with pronounced antioxidative and anti-inflammatory activities. The antitumour promoting activity of [6]-gingerol, a major pungent principle was investigated in skin carcinogenesis model. Topical application of [6]-gingerol on to shaven backs of female ICR mice prior to each topical dose of 12-O-tetradecanoylphorbol-13-acetate (TPA) significantly inhibited 7, 12-dimethylbenz[a]anthracene-induced skin papillomagenesis. The compound also suppressed TPA-induced epidermal ornithine decarboxylase activity and inflammation.

Anti ulcer principles

Researchers detected an anti-ulcer principle, 6-gingesulfonic acid, and three monoacyl digalactosyl glycerols, ginger glycolipids A, B, and C, from ginger rhizome from Taiwan. Dried rhizome of ginger, is used in Chinese and Japanese traditional medicines to treat headaches, nausea, stomach-ache and colds. The structures of 6-gingesulfonic acid and gingerglycolipids A-C were elucidated from chemical and physicochemical analyses. Studies conducted by Usha et al observed higher uptake of iron, zinc and calcium by the intestinal segments of spice-fed animals. The increase in the mineral uptake was the highest for calcium with >100% in some cases. The positive influence of dietary capsaicin was more pronounced on zinc uptake as compared to that of iron. Uptake of the glutamic acid standard was 87% and 62% higher in rats fed piperine and ginger. The higher intestinal uptake of iron and zinc as a result of consumption of pungent spices could encourage a strategy to reduce deficiency of these trace elements prevalent in population dependent on plant based foods.

Anticonvulsive and analgesic effect

Ginger is known to warm the body, curing chills caused by the common cold. An acetone extract of ginger rhizomes (administered orally) significantly inhibited serotonin-induced hypothermia and serotonin-induced diarrhoea. When the extract was fractionated on silica gel, the main active constituent against both disorders was found to be [6]-shogaol. Other anticathartic components were [6]-dehydrogingerdione, [8]-gingerol and [10]-gingerol.

Cardio vascular effect

Aqueous ginger extract lowers BP through a dual inhibitory effect mediated via stimulation of muscarinic receptors and blockade of Ca++ channels and this study provides sound mechanistic basis for the use of ginger in hypertension and palpitations.Based on clinical trials it is postulated that a 5% solution of essential oil of ginger is an effective post-operative nausea and vomiting (PONV) prevention when administered preoperatively, naso-cutaneously concurrently with conventional therapies to general anaesthesia patients at high risk for PONV.

Gingerols, the pungent constituents of ginger, were assessed as agonists of the capsaicin-activated vanilloid receptor (VR1). [6]-Gingerol and [8]-gingerol evoked capsaicin-like intracellular Ca^{2+} transients and ion currents in cultured dorsal root ganglion neurons. These effects of gingerols were blocked by capsazepine, the VR1 receptor antagonist. The potency of gingerols increased with increasing size of the side chain and with the overall hydrophobicity in the series. It is concluded that gingerols represent a novel class of naturally occurring VR1 receptor agonists that may contribute to the medicinal properties of ginger, which have been known for centuries. The gingerol structure may be used as a template for the development of drugs acting as moderately potent activators of the VR1 receptor.

Turmeric

Numerous evidences indicate that curcumin is potentially effective and safe. U.S. Food and Drug Administration have approved curcumin as a “Generally Regarded as Safe” compound and the daily intake of curcumin at a dose of 0.1-3 mg/kg-BW has been considered as an acceptable dose by the Joint FAO/WHO Expert Committee on Food Additives, 1996. In spite of this, the use of curcumin is mainly limited because of its poor pharmacokinetic and pharmacodynamic profile, i.e., poor absorption, short half-life and rapid metabolism in the GI tract. Phase I clinical trials have indicated that curcumin is safe even at a dose of 12 g/day in humans but exhibits relatively poor bioavailability. Curcumin, derived from turmeric possesses a diverse array of biological activities. These range from its anti-inflammatory, antineoplastic, and metabolic modifying properties to surprising roles in disorders ranging from Alzheimer’s disease to cystic fibrosis. Its effects on growth factor receptors, signaling molecules, and transcription factors, together with its epigenetic effects are widely considered to be extraordinary. These pleiotropic attributes, coupled with its safety even when used orally at well over 10 g/day, are unparalleled amongst pharmacological agents. However, there is one drawback; apart from the luminal gastrointestinal tract where its pharmacology predicts that reasonable drug levels can be attained, its broader use is hampered by its poor solubility and hence near undetectable plasma levels.

Anti-inflammatory activity

Curcuminoids and other constituents of turmeric are well-known for their anti-inflammatory activity. Turmeric extract, volatile oils from turmeric and curcuminoids were reported to possess this property in different experimental models of inflammation in mice, rats, rabbits and pigeons. Administration of curcuminoids to patients who underwent surgery or suffered from trauma, could reduce inflammation to a comparable level with phenylbutazone. Oral administration of curcumin at a dose of 3 mg/kg was also found to be effective in reducing inflammation associated with various forms of arthritis. The anti rheumatic properties of curcuminoids were also tested successfully in patients with diagnosed rheumatoid arthritis. Curcumin has also been shown to have significant wound healing properties.

It acts on various stages of the natural wound healing process to hasten healing. The highlighted studies in the review provide evidence of the ability of curcumin to reduce the body's natural response to cutaneous wounds such as inflammation and oxidation. Curcumin is shown to posess ability to enhance granulation tissue formation, collagen deposition, tissue remodeling and wound contraction. It has become evident that optimizing the topical application of curcumin through altering its formulation is essential to ensure the maximum therapeutical effects of curcumin on skin wounds. The protective effects of curcumin on experimentally induced inflammation, hepatotoxicity, and cardiotoxicity using various animalmodels with biochemical parameters like serum marker enzymes and antioxidants in target tissues.Inaddition,liver andcardiac histoarchitecture changeswerealsostudied.Curcumin treatment inhibited carrageenin and albumin induced edema,cotton pellet granuloma formation. . In in vitro experiments curcum ininhibited iron catalyzed lipid peroxidation in liver homogenates,scavenged nitric oxide spontaneously generated from nitroprusside and inhibited heat induced hemolysis of rat erythrocytes.In vitro and in vivo experimental findings suggest the protective effect of curcumin on experimentally induced inflammation, hepatotoxicity, and cardiotoxicity in rats. Curcumin also enhances wound healing in diabatic rats and mice and in H_2O_2 induced damage in human keratinocytes and fibroplasts.

Anto-oxidant effect

Dhanalakshmi and Jaganmohanrao L conducted a study to correlate antioxidant and radical scavenging potentials with chemical composition of turmeric oils. Major components were ar-turmerone (21.0–30.3%), α-turmerone (26.5–33.5%) andβ -turmerone (18.9–21.1%). Trolox equivalent antioxidant capacity (TEAC) values were 38.9, 68.0 and 66.9 μM at 1 mg of oil/ml for fresh, dried and cured rhizome respectively in ABTS assay. IC_{50} values for fresh, dried and cured rhizome oil to quench DPPH radicals were 4.4, 3.5 and 3.9 mg of oil/ml respectively. Fresh, dried and cured rhizome oils showed antioxidant capacity of 358, 686 and 638 mM of ascorbic acid equivalents per 1 mg of oil respectively

Curcuminoids are natural phenolic compounds with potent anti-oxidant properties, which were reported as early as 1975. Both turmeric and curcumin inhibit generation of super oxide and hydroxyl free radicals. The antioxidant properties of curcumin in the prevention of lipid peroxidation are also well-recognized. The three forms of the pigment have dual prolonged antioxidant activity *viz*; preventing the formation of free radicals as well as intervening in their propagation. The anti-oxidant activity has been attributed to its unique conjugated structure which includes two methoxy phenols and an enol form of β-diketone, with the typical radical trapping ability as a chain breaking anti-oxidant.

Antimutagenic and Anticancerous property

Curcumin, a natural anticancer agent, has been shown to inhibit cell growth in a number of tumor cell lines and animal models. Caia et al examined the inhibition of curcumin on cell viability and its induction of apoptosis using different gastric cancer cell lines (BGC-823, MKN-45 and SCG-7901). 3-(4,5-dimethyl-thiazol-2-yl)- 2-5-diphenyltetrazolium-bromide (MTT) assay showed that curcumin inhibited cell growth in a dose- (1, 5, 10 and 30 μM) and time- (24, 48, 72 and 96 h) dependent manner; analysis of Annexin V binding showed that curcumin induced apoptosis at the dose of 10 and 30 μM when the cells were treated for 24 and 48 h. Their biological function included cell proliferation cycle and apoptosis (20%), metabolism (16%), nucleic acid processing (15%), cytoskeleton organization and movement (11%), signal transduction (11%), protein folding, proteolysis and translation (20%), and immune response (2%). Furthermore, protein–

protein interacting analysis demonstrated the interaction networks affected by curcumin in gastric cancer cells. These data provide some clues for explaining the anticancer mechanisms of curcumin and explore more potent molecular targets of the drug expected to be helpful for the development of new drugs.

Curcumin is reported to prevent DNA damage even in individuals who may be genetically susceptible to toxic effects of xenobiotic exposures and is also able to exert antimutagenic/ anticarcinogenic properties at levels as low as 0.1–0.5% in the diet (Chempakam and Parthasarathy 2008).Deketene curcumin is formed as a consequence of pyrolysis during common household cooking, showed stronger anti-cancer effects than curcumin.

Telomerase is a multi-subunit ribonucleoprotein enzyme comprised of the telomerase reverse transcriptase (TERT), the telomerase RNA (TR), and species-specific accessory proteins. TERT catalyzes the addition of a short repetitive telomeric sequence onto the 30-end of telomeres using a section of TR as the template in a process known as repeat addition processivity. This elongation mechanism requires a translocation step of the previous round of telomerase-extended product to the original position on the RNA template before the new round of telomeric repeat can be reverse transcribed onto the telomeric end. The length of telomeres controls the life span of eukaryotic cells. Telomerase maintains the length of telomeres in certain eukaryotic cells, such as germline cells and stem cells, and allows these cells to evade replicative senescence. Thanachai et al (2014) reported a number of curcuminoid derivatives that enhance telomerase activity in an in vitro TRAP assay. A preliminary analysis of structure–activity relationships found that the minimal requirement for this enhanced telomerase activity is a curcuminoid core with at least one n-pentylpyridine side chain, while curcuminoids with two such side chains exhibit even greater activity. The finding here might lead to a new class of telomerase activators that act directly or indirectly on telomerase, rather than through the reactivation of the telomerase reverse transcriptase (TERT) gene associated with other telomerase activators.

Chemopreventive and bioprotectant property

Numerous studies have been published on the positive effects of turmeric, both in the prevention of cancer and in the recovery from chemotherapy and radiation treatment. In addition to its capacity to intervene in the initiation and growth of cancer cells and tumors and to prevent their subsequent spread throughout the body by metastasis, curcumin increases cancer cells' sensitivity to certain drugs commonly used to combat cancer, rendering chemotherapy more effective.

Curcuminoids can also act as photochemoprotective agents that provide protection against UV B radiation induced oxidative stress. This inhibition of UV B radiation induced damage can reduce the incidence of skin cancer.

Antidiabetic property

The efficacy of turmeric and curcumin on blood sugar and polyol pathway in diabetic albino rats showed significant reduction in blood sugar and glycosylated hemoglobin levels. This could be due to decreased influx of glucose into the polyol pathway, leading to an increased NADPH/NADP ratio and elevated activity of the antioxidant enzyme glutathione peroxidase. The activity of sorbitol dehydrogenase, an enzyme that catalyzes the conversion of sorbitol to fructose, is also lowered significantly on treatment with turmeric or curcumin. A 9-month curcumin intervention in a prediabetic population significantly lowered the number of prediabetic individuals who eventually developed Type 2 DM. In addition, the curcumin treatment appeared to improve overall function of β-cells, with very minor adverse effects .Ethanol extracted curcumin was able to substantially and significantly prevent type 2 diabetes in the pre diabetic population. Dietary curcumin can alleviate dangerous secondary complications induced by diabetes. The beneficial effects of dietary curcumin on diabetic nephropathy is probably mediated through the hypolipidemic effects of curcumin. Research for more than two decades on curcumin (diferuloylmethane) has revealed the pleiotropic nature of the biological effects of this molecule. This natural polyphenolic compound exerts its beneficial effects by modulating different signaling molecules including transcription factors, chemokines, cytokines, tumor suppressor genes, adhesion molecules, microRNAs, etc. Oxidative stress and inflammation play a pivotal role in various diseases like diabetes, cancer, arthritis, Alzheimer's disease and cardiovascular diseases. Curcumin, therefore, could be a therapeutic option for the treatment of these diseases, provided limitations in its oral bioavailability can be overcome.

Curcumin has been proved to be an effective hypolipidaemic agent. One study validated the role of dietary curcumin in maintaining healthy serum cholesterol levels in diabetic rats. Employing a high cholesterol diet for the diabetic rats, curcumin exhibited lowering of cholesterol and phospholipid in treated animals as compared to curcumin-free controls. Liver cholesterol, triglycerides and phospholipid elevated under diabetic conditions were lowered by dietary curcumin. Curcumin induces a higher rate of cholesterol catabolism which is evidenced by the higher activity of liver cholesterol-7α-hydroxylase.

Anti-angiogenic effect

Studies on the effect of curcumin on the growth of Ehrlich ascites tumor cells and endothelial cells *in vitro* proves curcumin to be a potent angioinhibitory compound, as demonstrated by inhibition of angiogenesis in two angiogenesis assay systems *in vivo*, *viz*. peritoneal angiogenesis and chorioallantoic membrane assay. The angioinhibitory effect of curcumin *in vivo* is corroborated by the results on down-regulation of the expression of proangiogenic genes by curcumin.

Hepatoprotective Effect

Curcumin and turmeric protect the liver against several toxicants both *in vitro* and *in vivo*. Oral administration of curcumin (30 mg/kg body weight) for 10 days lowered the liver and serum lipid peroxide levels, serum alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT) and lactate dehydrogenase (LDH), enhanced by i.p. injection of iron in rats.

Protection from Alzheimer's disease

Alzheimer's disease (AD) is a devastating neurodegenerative disease with progressive loss in memory. AD is characterized by the deposition of the senile plaques mainly composed of β-amyloid (Aβ) fragment and neurofibrillary tangles. Despite intensive advancement in research, available therapeutic options are limited, thus, increasing demand for new drugs. In the recent past, medicinal plants attracted attention due to their potential role in dementia.

Curcuminoids (a mixture of curcumin, bisdemethoxycurcumin and demethoxycurcumin) reported to possess acetylcholinesterase (AChE) inhibitory and memory enhancing activities useful in Alzheimer's disease (AD). Touqeer and, Anwarul-Hassan found Curcuminoids inhibited AChE in the in-vitro assay with IC_{50} value of 19.67, bisdemethoxycurcumin 16.84, demethoxycurcumin 33.14 and curcumin 67.69 μM. In the ex-vivo AChE assay, curcuminoids and its individual components except curcumin showed dose-dependent (3–10 mg/kg) inhibition in frontal cortex and hippocampus. When studied for their effect on memory at a fixed dose (10 mg/kg), all compounds showed significant ($p<0.001$) and comparable effect in scopolamine-induced amnesia. These data indicate that curcuminoids and all individual components except curcumin possess pronounced AChE inhibitory activity. Curcumin was relatively weak in the in-vitro assay and without effect in the ex-vivo AChE model, while equally effective in memory enhancing effect, suggestive of additional mechanism(s) involved. Thus curcuminoids mixture might possess better therapeutic profile than curcumin for its medicinal use in AD.

.

Cinnamon

Cinnamon is used as an ingredient in many ‘ayurvedic’ and ‘Unani’ medicinal preparations. The bark of *C. zeylanicum* is an aphrodisiac, anthelmintic and tonic. It is useful in the treatment of ‘vata’, biliousness, parched mouth, bronchitis, diarrhoea, itching, heart diseases and urinary diseases. The bark is a carminative and expectorant; it is useful in hydrocele, flatulence, headache, piles etc. Cinnamon possesses various biological activities such as antioxidant, antimicrobial, antidiabetic and antiallergic activities.

Antioxidant activity

Cinnamon and its essential oil are used as preservatives in food from ancient time. It is due to the antioxidant property of cinnamon. Deterioration of food is due to lipid peroxidation. *In vivo* lipid peroxidation causes tissue damage, which can lead to inflammatory diseases. Phenolic compounds such as hydroxy cinnamaldehyde and hydroxycinnamic acid present in the cinnamon extract act as scavengers of peroxide radicals and prevent oxidative damages.

Anti-inflammatory activity

Cinnamon is reported to possess anti-inflammatory activity. The ethanolic extract (70%) of cinnamon was effective on acute inflammation in mice. An herbal ophthalmic preparation called *'Opthacare'* containing 0.5% cinnamon was found to be effective as anti-inflammatory agent on ocular inflammation in rabbits.

Antidiabetic activity

Cinnamon has been used as a spice and as traditional herbal medicine for centuries. The available in vitro and animal in vivoevidence suggests that cinnamon has anti-inflammatory, antimicrobial, antioxidant, antitumor, cardiovascular, cholesterol lowering, and immunomodulatory effects. In vitro studies have demonstrated that cinnamon may act as an insulin mimetic, to potentiate insulin activity or to stimulate cellular glucose metabolism. Furthermore, animal studies have demonstrated strong hypoglycemic properties.

The use of cinnamonas an adjunct to the treatment of type 2 diabetes mellitus is the most promising area.

Ting et al., performed a randomized, double blinded clinical study to analyze the effect of cinnamon extract on glycosylated hemoglobin A1c and fasting blood glucose levels in Chinese patients with type 2 diabetes. A total of 66 patients with type 2 diabetes were recruited and randomly divided into 3 groups: placebo and low-dose and high-dose supplementation with cinnamon extract at 120 and 360 mg/d, respectively. Patients in all 3 groups took gliclazide during the entire 3 months of the study. Both hemoglobin A1c and fasting blood glucose levels were significantly reduced in patients in the low- and high-dose groups, whereas they were not changed in the placebo group. The blood triglyceride levels were also significantly reduced in the low-dose group. The blood levels of total cholesterol, high density lipoprotein cholesterol, low-density lipoprotein cholesterol, and liver transaminase remained unchanged in the 3 groups. In conclusion, their study illustrated that cinnamon supplementation is able to significantly improve blood glucose control in Chinese patients with type 2 diabetes.

Therapeutic studies have proved the potential of cinnamaldehyde as an antidiabetic agent. Cinnamaldehyde inhibits aldose reductase, a key enzyme involved in the 'polyol' pathway. This enzyme is shown to catalyse the conversion of glucose to sorbitol, in insulin insensitive tissues in diabetic patients. This leads to accumulation of sorbitol in chronic complication of diabetes such as cataract, neuropathy and retinopathy. Aldose-reductase inhibitors prevent conversion of glucose to sorbitol, thereby preventing several diabetic complications.

Antipyretic and analgesic effects

A decoction of dried twigs of cinnamon can produce antipyretic effect in mice. Studies conducted in anaesthetized dogs and guinea pigs indicated that cinnamaldehyde or sodium cinnamate also produced the hypothermic and antipyretic effects (Chinese Materia Medica). It also causes hypotensive effect, which is mainly due to vasodilation of peripheral vessels. Cinnamaldehyde produced analgesic effect in mice.

Clove

Clove is one of the most valuable spices that have been as food preservative and for many medicinal purposes. India's traditional Ayurveda healers have used cloves since ancient times to treat respiratory and digestive ailments. Like many culinary spices, cloves help relax the smooth muscle lining of the digestive tract and eating cloves is said to be aphrodisiac. Cloves are more often used to assist the action of other herbal remedies rather than alone. It is spicy, warming, stimulant, anodyne, anesthetic (topical), anti-emetic, anti-griping (added to other herbs), vermifuge, uterine stimulant, stomachic, aromatic, carminative, antiseptic, antiviral, antibacterial, antifungal, antispasmodic, expectorant, aphrodisiac, promotes salivation and digestive juices; Oil is expectorant, anesthetic, emmenogogue; affects kidney, spleen, stomach and has preservative properties. In Chinese medicine cloves are used as a kidney tonic (especially for impotence associated with deficient yang), to warm the body, increase circulation and as a digestive aid. It is also used for nausea, vomiting, flatulence, hiccups, stomach chills, fever, caries, toothache, cholera, colic, cracked nipples, diarrhea, dyspepsia, halitosis (chewing on the whole clove), unusual uterine bleeding, nasal polyps, and impotence. The root is used for a weaker effect. The oil is employed for diarrhoea, halitosis, hernia, nausea, and toothache.

Ethanolic extract (50%) of clove produced a significant and sustained increase in the sexual activity of normal male rats, without any conspicuous gastric ulceration and adverse effects. Thus, the resultant aphrodisiac activity of the extract lends support to the claims for its traditional usage in sexual disorders. In traditional Chinese medicine it is used to treat indigestion, diarrhea, hernia, and ringworm and other fungal infections. In Ayurveda cloves are used to treat respiratory and digestive ailments, flatulence, nausea and vomiting. The medieval German herbalists used cloves as part of anti-gout mixture. Clove is believed to have a cooling effect on stomach. A paste of clove was applied on the forehead for relief from colds. It has powerful local antiseptic and mild anesthetic actions. Clove bud oil has various biological activities such as antibacterial, antifungal, antioxidant and insecticidal properties. The high level of eugenol present in the essential oil imparts strong biological activity and antimicrobial activity. The clove oil is used to prepare microscopic slides for viewing. It is used to treat flatulence, colic, indigestion and nausea. Eugenol is used in germicides and perfumes, in the synthesis of vanillin, and as a sweetener or intensifier.

Antimicrobial activity

Clove is shown to exhibit antimicrobial activity against *Bacillus subtilis*, *Escherichia coli* and *Saccharomyces cerevisiae.* Essential oils from clove and eugenol showed various degrees of inhibition, against *Aspergillus niger, Saccharomyces cerevisiae, Mycoderma sp., Lactobacillus acidophilus* and *Bacillus cereus*, as estimated by paper disc agar diffusion method . The oil also inhibited the growth of *Fusarium verticilloides*. Clove oil (1% v/w) inhibited *Listeria monocytogenes* in chicken frankfurters. It has excellent antimicrobial properties and is used in food preservation.

Clove extracts showed high antifungal activity against *Rhizoctonia solani*. Clove oil and eugenol are reported to possess significant antifungal activity against rye bread spoilage fungi . Clove oil showed antifungal activity against the fungi belonging to *Eurotium, Aspergillus* and *Penicillium* species commonly causing deterioration of bakery products. Eugenol possessed antifungal activity against *Cladosporium herbarum, Penicillium glabrum*, *P. expansum* and *Aspergillus niger* .

Antibacterial activity

Cloves are one of Mother Nature's premium antiseptics. A few drops of the oil in water can stop vomiting and an infusion relieves nausea. Essential oil of clove is effective against *Streptococci*, *Staphylococci* and *Pneumomocci* bacteria.The volatile oils of clove exhibited considerable inhibitory effects and antibacterial activity against several genera of bacteria including animal and plant pathogens and food poisoning and spoilage bacteria.

Clove kills intestinal parasites and exhibits broad anti-microbial properties thus supporting its traditional use as a treatment for diarrhoea, intestinal worms, and other digestive ailments. Clove essential oil is strongly antimicrobial, antiseptic, hemostatic and anti-inflammatory. Clove oil showed antimicrobial activity against some human pathogenic bacteria, resistant to certain antibiotics.

Antioxidant activity

Researchers found high correlation between the polyphenols content and the antioxidant activity. Clove (buds) was the spice presenting higher antioxidant activity and polyphenol content. The major types of phenolic compounds found were phenolic acids (gallic acid), flavonol glucosides, phenolic volatile oils (eugenol, acetyl eugenol) and tannins. It was highlighted the huge potential of clove as radical scavenger and as a commercial source of polyphenols.

Clove essential oil has the highest anti-oxidant capability of any essential oil, perhaps one of the highest known for a food or supplement. It has been included in some 'longevity' formulae for this reason. Clove and eugenol possessed strong antioxidant activity, which is comparable with the activities of the synthetic antioxidants, BHA and pyrogallol. Essential oil from clove leaf possesses scavenging activity against the 2, 2-diphenyl-1-picryl hydrazyl (DPPH) radical at concentrations lower than the concentrations of eugenol, butylated hydroxytoluene (BHT), and butylated hydroxyanisole (BHA). It also showed a significant inhibitory effect against hydroxyl radicals and acted as an iron chelator. Clove oil is also commonly used for numbing tooth pain, and the healing of mouth and gum sores. The oil can also be used to assist breaking of tobacco addiction (Ananda Aromatherapy). The antioxidant activity of clove bud extract and its major aroma components, eugenol and eugenyl acetate, were comparable to that of the natural antioxidant, α-tocopherol.

Anti-inflammatory activity

Eugenol, the primary component of clove's volatile oils, functions as an anti-inflammatory substance. In animal studies, the addition of clove extract to diets already high in anti-inflammatory components (like cod liver oil, with its high ω-3 fatty acid content) brings synergistic effect. In some studies, it further reduces inflammatory symptoms by another 15-30%. Clove also contains a variety of flavonoids, including kaempferol and rhamnetin, which also contribute to clove's anti-inflammatory and antioxidant properties. Another constituent of clove oil, β-caryophyllene, also contribute to the anti-inflammatory activity.

Anesthetic effect

Clove oil is used as a safe anesthetic for channel catfish. Clove oil and eugenol were reported as acceptable anesthetic for rabbit fish (*Saiganus lineatus*), coral reef fish (*Pomacentrus amboinensis*) and rainbow trout (*Oncorhynchus mykiss*) for use in aquaculture and aquatic research. It was also found to be useful as a crab anesthetic. β-caryophellene is also reported to be an anesthetic.

Mosquito repellent activity

Clove oil exhibited repellent activity on *Anopheles albimanus*, *Aedes aegypti, Anopheles dirus* and *Culex quinquefasciatus*.

Insecticidal activity

Eugenol, isoeugenol and methyl eugenol caused contact toxicity to the storage pathogens, *Sitophilus zeamis* and *Tribolium costaneum*. These compounds had similar toxicity to *S. zeamis* at the LD_{50} 30 µg/ mg insect, while for *T. costaneum* the order of potency was isoeugenol > eugenol> methyl eugenol. The clove leaf and bud oils showed potent insecticidal activity against the human head louse (*Pediculus capitis*).

Antithrombotic activity

Clove oil inhibited human platelet aggregation induced by arachidonic acid (AA), platelet-activating factor (PAF) or collagen. Clove oil was a more effective inhibitor for aggregation induced by AA and PAF (IC_{50}: 4 and 6 µM respectively) than collagen (IC_{50}: 132 µM). It inhibits platelet aggregation and thromboxane synthesis and acts as anti-thrombotic agent. Eugenol and acetyl eugenol were more potent than aspirin in inhibiting platelet aggregation induced by arachidonate, adrenaline and collagen. In arachidonate-induced aggregation eugenol was on par with indomethacin.

Anticancerous activity

Clove has strong anticancerous property. The sesquiterpenes, β-cayophyllene, β-cayophyllene epoxide, α-humulene, α-humulene epoxide and eugenol present in clove oil showed potential anticarcinogenic activity by inducing the detoxifying enzyme, glutathione-S-transferase in mouse liver and small intestine.

Antipyretic effect

Eugenol, the chief a constituent of clove oil, has marked antipyretic activity when given intravenously, intragastrically and centrally, to rabbits made febrile by interleukin 1. Eugenol was more effective in reducing fever than acetaminophen and it reduced fever primarily through central action that is similar to that of common antipyretic drugs such as acetaminophen.

Nutmeg

Nutmeg is more commonly used in Oriental than in Western medicine. Medicinally it is known for its stimulative and carminative properties. The seeds are carminative, stomachic, astringent, deodorant, narcotic, aphrodisiac and useful in flatulence, nausea, and vomiting. Nguyen et al reported that nutmeg and its active constituents can be used not only for the development of agents to treat obesity and possibly type-2 diabetes but may also be beneficial for other metabolic disorders.

Oil of nutmeg is useful in the treatment of inflammation of the bladder and urinary tract, halitosis, dyspepsia, flatulence, impotence, insomnia and skin diseases. It is also used externally as a stimulant and ointment as a counterirritant. Essential oil contains several compounds, most of which are valuable in industry. Most of the pharmacological properties of nutmeg are attributed to the compounds present in the essential oil. Mace oil possesses almost identical physiological and organoleptic properties as nutmeg oil. Nutmeg butter is a mild external stimulant used in the form of ointments, hair lotions and plaster, and used against rheumatism, paralysis and sprains.

Another application of nutmeg essential oils is in aromatherapy, which is gaining importance these days. The main constituents of nutmeg and mace- myristicin, elemicin and isoelemicin - when presented in aroma form, act as stress relievers.

Both nutmeg and mace contain the active ingredient myristicin, which possesses narcotic properties. Nutmeg butter also contains elemicin and myristicin, which cause psychotropic effects. Ingestion in large quantities produces narcosis, delirium, drowsiness, epileptic convulsions and even death. It also causes temporary constipation and difficulty in urination and increased fat deposition in liver. Powdered nutmeg is used occasionally as a hallucinogenic drug, but such use is dangerous as excessive dose of mace has a narcotic effect and symptoms of delirium and epileptic convulsions appear after 1-6 hours of consumption.

Anticarcinogenic activity

The essential oil of nutmeg possesses excellent anticarcinogenic activity, which has been documented well in studies involving animals. The essential oil interferes with the activities of the host enzymes associated with activation and detoxication of xenobiotic compounds, including chemical carcinogens and mutagens.

Bio- intensive pest management on Seed Spice Crops.

Krishna Kant
National Research Centre on Seed Spices, Tabiji, Ajmer-Rajasthan

Spices comprise fragrant products of plant origin used for flavouring food and beverages. Among different group of spices, seed spices includes the single largest group of spices coming under it. The important amongst this group are coriander, cumin, fennel fenugreek, celery, ajwan dill, anise etc. The seed spices are used in whole and processed form for imparting aroma and pungency to food. They are commonly used to season the food dishes and products. Most of the seed spices belong to family Apiaceae except fenugreek and Nigella which are from family Fabaceae and Ranunculaceae, respectively and have their centre of origin primarily in Mediterranean region and South Europe. Seed spices are mainly cultivated in the state of Rajasthan and Gujarat at commercial level and on smaller scale in other state like Madhya Pradesh, Punjab, Uttar Pradesh, Bihar and Andhra Pradesh etc.

Seed spices crops are extensively cultivated in the arid to semi-arid region of India during rabi season covering an area of about 8.5 lakh ha with production of 5.6 lakh tonnes annually (Table-1). In India, Rajasthan and Gujarat states have emerged as "Seed Spices Bowl" and together contribute more than 80% of the total seed spices production in the country. Out of the 20 seed spices grown in India, the most important are coriander, cumin, fennel and fenugreek. Few other seed spices crops like ajwan, dill, Nigella and celery are also grown in smaller areas in the different parts of the country. Seed spices are also exported in large quantities earning foreign exchange. Year 2004-05, 75100 t of seed spices were exported earning foreign exchange worth Rs 259.7 crores (Table-2).

Table-1. Area, production, productivity and export of seed spice in India (2005-06)

S. No	Seed Spices	Area (000 ha)	Production (000 t)	Productivity
1	Coriander	352.07	253.91	0.7211
2	Cumin	403.03	199.85	0.4958
3	Fennel	45.91	61.31	1.3354
4	Fenugreek	32.66	35.71	1.0933
5	others	26.03	11.58	0.4448
Total		859.70	562.36	4.0904

Table-2. Export of seed spices from India (2004-05)

S. No.	**Seed Spices**	**Quantity of Export (t)**	**Cost (Rs. In Lakh)**
1	Coriander	33750	8266
2	Cumin	13750	10190
3	Fennel	7100	2530
4	Fenugreek	13750	2661
5	others	6750	2323
total		75100	25970

Insect pests Complex of Seed Spices:

The common insect pests of seed spices are sucking pests (devitalizing plant through sap sucking and transmitting diseases are aphids, jassids bugs, whitefly and mites),seed borer (midge) defoliators (damaging leaves like caterpillars, weevils, beetles, miners etc.) and those involved in damage during storage. (Table-3). Most of these pests are polyphagous, attacking variety of vegetation and a few species are exclusive for seed spices. Some of the species causes heavy losses to the crop.

Table 3. Insect Pests complex of Seed Spices

Pests Complex	**Crop Stages**	**Common insect pests**
Soil Insects	Seed germination to vegetative growth	Termite , White grubs and cut worm
Leaf minors	Early vegetative growth	Leaf minor
Sucking pests	Vegetative stage to fruit maturity stage	Aphids, White fly, mite, Jassids, Thrips, Hoppers, Seed bug etc.
Seed/Fruit borer	Seed development stage to seed harvesting stage	Seed midge
Defoliators	Vegetative stage to seed maturity stages	*Helicoverpa armigera* and *Spodoptera litura*
Storage pests	Al storage	Cigarette beetle and Drug store beetle

At field level maximum yield loss in most of seed spice crops are caused by sucking pests especially aphids. Defoliators like *Spodoptera litura* and *Helicoverpa armigera* are also cause substantial losses especially in fenugreek. Cigarette beetle *Lasioderma serricorne* and drug store beetle *Stegobium panicum* are major species found infesting the seed during storage. Aphids (Myzus *persicae, Brevicoryne coriandri, Acyrthosiphon pisum, Aphis gossypii, Hyadaphis coriander and A. craccivora*) thrips (Thrips tabaci) mite (Petrobia lateens) jassids, Seed midge (*Systole albipennis*) , *Spodoptera litura* and *Helicoverpa armigera* are reported important pests of Fennel, Cumin. Coriander, Dill, Celary and Fenugreek.

A- Major Insect –Pests of Seed Spices

1-Aphids : Aphids are major pests of seed spices and causes significant losses in crop yield. Coriander is attacked by more than one species of aphids. *Hyadaphis coriandri* (Das) is main aphids of coriander and have worldwide distribution Aphis gossypii Glover, *Myzus persicae* (Sulzer), *Aphis spiraecola, Brevicornyne coriandri* and *Aphis critricola* has also been reported infesting coriander crops. There are five species of aphids found infesting cumin crop. However *Myzus persicae* and *Aphis gossypii* is main aphids species reported from Rajasthan and Gujarat. Other species found attached with cumin crop are *Brevicoryne coriandri*, *Acyrthosiphon pisum* and A. craccivora. In fennel crop *Hyadaphis coriandri* is main aphids species in India . However in Europe and North America *Hyadaphis foeniculi* and in Egypt *Aphis fabae* is major aphid species of fennel crop. There are three species of aphids are reported infesting fenugreek crop is

Acyrthosiphon pisum Aphis craccivora and *Myzus persicae* The heavy infestation of aphid on coriander occurred between December to march and cause the loss of more than 50% of yield in unprotected crop . In cumin and damage was exceeded up to 40.5 per cent. When the aphid infestation occurs at flowering and fruit stage, the fruits are not formed and, if they are formed, they are shrivelled and of poor quality .Higher losses in yield could be caused by a small number of aphids infesting the crop at the beginning of flowering than by a large number of aphids at the grain filling stage *Aphis gossypii* Glover is found attacking cumin in Rajasthan, is vector of mosaic. Fennel, fenugreek, anise also suffer heavy losses in yield due to aphids infestation.

2-Seed Midge (*Systole albipennis*) : *Systole albipennis* Walker is specific pest found to attack dill, coriander, fennel, cumin and ajwan and has been reported from Asia, Africa and Europe, whose larva damage the fruit and survive in them. Infestation occure at field level but infestation found continue during storage of seed. The egg laid by female midge in the seed and developing larva feeds upon and destroys the embryo and/or endosperm consequently. Approximately 40 percent in fennel, 30 percent in coriander, 27 percent in dill, 20 percent in cumin and 10 percent in ajawan seed damage has been reported at field level. .

3-Phytophagous Mites : Among the other sucking pests the tetranychidae mite *Petrobia latens* is another serious pest on coriander and cumin. It found infesting semi arid and arid region and causes appreciable damage to coriander and cumin crop in in Rajasthan. In cumin the infestation occurs mainly in the flowering stage, early sown crop evade the peak period of activity of the mites. The red spider mite *Tetranychus telaris* L. reported heavy infestation in coriander crop at Guntor,(AP) which reduces more than 50% yield of coriander crop.

4-White fly (*Bemisia tabaci*) : White fly *(Bemisia tabaci)* a serious pest of many important crop. In seed spices it is its infestation has been reported in fenugreek, coriander and fennel. Heavy infestation of white fly is reported from Andhra Pradesh on coriander, fenugreek and in fennel crop

5-Jassids (*Empoasca Kerri* Pruthi) : The jassids Empoasca Kerri are also commonly observed on many seed spice crops. Its serious infestation is reprted on fenugreek crop. They are more serious when they occur in the seedling stage, secreting toxin and hampering growth of seedling.

6-Stink bugs : *Agnoscelis nubila* infest flowers of coriander and cumin and suck sap, resulting in smaller sized seed or its non- formation. The other bug infesting seed spice crops is *Nazara viriduala*.

7-Thrips : *Thrips tabaci* is a serious pests of cumin in Rajasthan and Gujarat. In cumin thrips population develop in early stages of the crop and cause heavy losses. It is also pests of fenugreek, fennel, dill and coriander. *Thrips tabaci* and *Scirtothrips dorsalis* has been found feeding on fennel and dill in Punjab. It was found that fennel was infested more than the dill. The infestation was heaviest between 20 March and 10 April on both crops that coincided with the main flowering period.

8-Bugs: Lygus bug (Nysus sp.) Coriadae bug (Cletus sp.) and Mirid bug(Megacoelum sp.) severely damaging various umbeliferous fruits during seed development to maturation stages. .

During their feeding, they pierce many cells and suck cell fluid. As in Umbelliferae, the endosperms mature more rapidly than the embryo. If feeding occurs in early stage of seed development, both endosperm and embryo are destroyed and whole of the endoplasm remains unaffected.

9-Leaf Minor (Liromyza spp.) : Leaf minor is start attacking on fenugreek crop at very early stages. It continue mine the leaves of fenugreek up to full vegetative stages /flowering stages. Excessive mining at early growth of the plant retarded the growth and vitality of the plants.
10-Defoliators : Most of seed spice crop are attacked by defoliators from flowering to seed maturation stages. The common species found on seed spice crops are *Spodoptera litura* S. exiqua and *Helicoverpa armigera*. *Spodoptera exigua*. Cut worm *Agrotis ipsilon* is another pest found in cumin, coriander and fennel and fenugreek crops. Defoliator of local origin *Hypera postica*, commonly called the alfalfa weevil reported from southern states infesting fenugreek crops from the first week of February until mid- March. Infestation of *Spodoptera litura* on fennel, fenugreek and nigella caused reduction of 15 to 20 percent yield . Heavy infestation of *Helicoverpa armigera* on cumin, fennel, dill and fenugreek has been reported from Gujarat .
k, humidity, seed moisture and type of storage. Cumin, coriander, ajowan and anise suffer most during the storage . About 20-30 percent damage has been found in one year of storage.

B-Application of Bio intensive methods for effective and economical pest management

Seed spice crop are high value crop and it exported in large quantity throughout the world. Presence of pesticide residues is one of great concern for our export especially to developed countries. We are not able to export our seed spice crop to some of country which have very high standard of regulation for pesticides and other contamination. There are numbers of technology developed by ICAR and Agricultural University which can be easily adopted and use for effective management of different pest with out heavy use of synthetic pesticides.

Seed spice crop mostely grown in the winter season and pesy of insect pests activity has been noticed from full vegetative stages to maturity stages.

Management of Pests:
1-Resistant Source:
Sucking pests are major yield reducing factors in most of the seed spices crops. Major seed spices crops like cumin, coriander, fennel and fenugreek has been screened against the sucking pests. None of variety showed complete resistant against the pests. However, variable degree of resistances shown by the different cultivars are given in the table -4.

Table-4. Resistance Source of Seed Spices against Aphids.

S. N.	Variety	Status	State
Coriander			
1.	ND COR – 35	Moderately Resistant	U.P
2.	RD – 44, DH – 205	Less Susceptible	W. Bengal
3.	DH - 254	Moderately Susceptible	
4.	UD – 686, RCr – 446, RCr – 436	Least Susceptible	Rajasthan
5.	RCr – 435, UD – 686, RC – 20, UD – 685, UD - 447	Moderately Susceptible	
6.	PKD – 5, PKD – 7, SKT – 3, CS – 7, PMIN – 5, MCS – 1, MCS – 5, UD - 20	Least Susceptible	M.P
7.	JCO – 115, UD – 686, JCO – 18, JCO – 130, GC – 43, RD – 23, UD - 255	antixenosis	Bihar
Cumin			
8.	UC – 187, UC – 154, UC – 150, UC – 88, UC – 33	Less Susceptible	Rajasthan
Fennel			
9	RC-7b,RC-9,RC-31b	Tolerance	Rajasthan
Fenugreek			
10.	Rmt – 1, UM – 129, PRT – 4	Least Susceptible	Rajasthan
11.	JF – 10, Um – 127, JF – 8, HM – 57, TG – 268, JG – 53	Moderately Susceptible	
12.	Sel 95 – 13	Resistant	Maharastra
13.	Sel – 38, Sel 95 – 11	Moderately Resistant	
14.	BDJ – 11, BDJ – 86, BDJ – 59, BDJ – 193, BDJ – 319, BDJ – 336, PLM – 78, PLM - 80	Moderately Susceptible	Punjab

2-Cultural Control-Sowing time of most of seed spices crops have direct correlation on buildup of pest population especially aphids. It has been found that early and timely sown crop escaped from severity of pest damage in most of the cases. Coriander and cumin crop sown between 15-30 October showed lower infestation of aphids and other pests.

3-Biological Control: The aphids of seed spices attracted number of parasitoides under field conditions. The population of parasitoides found increased with the increase of temperature in Rajasthan and Gujarat condition. Under greenhouse conditions the ectoparasite *Aphidius gifuensis* Ashn is used for biological control. The parasites *Aphaleeinus kurdijmovi* occurs regularly, reaches to its maximum (98 percent) which was observed during November-December. On artificial release, the parasitism increases gradually and reaches up to a maximum in 30 days.

The noctuids moth larvae *Spodoptera* and *Helicoverpa* attracted large number of parasitoides in field conditions. The common parasitoides are *Sturamia inconspicuoides*, *Actia monticola*, *Euplectrus gopimohani*. For managing noctuids moth larvae at field conditions 4-6 inaculative releases egg parasitoids 150,000 like *Trichogramma Chilonus*. *T. Brasielensis* @ 150000 parasitoides/ha or starting at first appearance of the moths at 1-15 days interval is found useful., release of larval parasitoids such as *Chilonus blackburnii* , *Bracon brevicornis* ,*Telenoums heliothinae* ,*Carcelia illota* ,*Coteria kazat* or *Campoletis cloridae*, take care of the already hatched larvae.

Coccinellied consist of major predator found feeding on various sucking pests of seed spices. Major coccnellid found predating on seed spices crops are, *Coccinella septumpunctata* L. *Bromoides suturalis* F. *Menoochilus sesxmacalatus* and *Adonia* sp. Predatory bird myna (*Acridotheres tristis*) was also found feeding on the aphid The other common predators of aphids are Chrysoperla carnea, Episyrphus balteatus and Ischiodon scutellaris.

4-Botanicals:

Application of Neem based commercial formulation like Neem Seed Kernal Extract(NSKE), Neem oil and commercial Neem formulation, karanj *(Pongamia* sp.) ,buken (*Melia* sp.) and pride of India (*Lagerstroemia indica*) has been found effective in controlling pest complex in various seed spices crops, especially in early control of pests.

5-Chemical Control:

For Sucking pests, Mite & Midge fallowing insecticides have been reported effective to manage the pests effectively. dimethoate 0.03%, thiamethoxam 0.025%, imidachlorprid 0.005%, acephate 0.03%, profenophos 0.05%, chlorpyriphos 0.05%, ethion 0.03% . for management of lepidopteron pests application of monocrotophos 0.05%, endosulfan – 0.05%, quinolphos – 0.05%, fenvalrate 0.02% and chlorpyriphos – 0.05% found effective against it.

Good production practices of raising Seed Spice Crops:

1. Recommended seed spices agronomic practices should be followed. A due care on selection of suitable variety and seed from reliable sources preferably possessing resistance/ tolerance to diseases.
2. The approach of integrated pest management (IPM) and integrated disease management (IDM) should be followed.
3. Integrated nutrient management and nitrated weed management strategies be followed.
4. The irrigation scheduling is necessary to be followed as it has relation with occurrence of few diseases such as cumin blight, wilts in coriander, cumin, powdery mildew in all seed spices crops.
5. In order to reduce presence of heavy metals, it is necessary to use safe water for irrigation purpose. The sewerage waste and water should be totally avoided for application in farm soils.

Mechanization in Spice Processing

E. Jayashree
ICAR-Indian Institute of Spices Research, Marikunnu P.O, Kozhikode 673012

Spices are high value export oriented crops extensively used for flavouring food and beverages, medicines, cosmetics, perfumery etc. Spices constitute a significant and indispensable segment of culinary art and essentially add flavour, colour and taste to the food preparations. India is the largest producer, consumer and exporter of spices in the world. India produces more than 65 spices out of the total 109 spices listed by International Standards Organisation (ISO). India produces around 5.8 million tonnes of spices annually (2012-13), of this about 10% of the total produce is exported to over 150 countries. The USA, Europe, Australia, Japan, the Middle East and Oceanic countries are the major importers of Indian spices. The estimated world trade in spices is 1.05 million tonnes valued at 2750 million US $, out of which India has a significant share of 48% in quantity and 43% in value.

Black pepper

Black pepper takes about 7-8 months after flowering to reach full maturity and is harvested during December-January in plains and from January-April in the high ranges of Western Ghats. It is important to harvest pepper at the proper stage of maturity in order to achieve a dried product of good colour and appearance. Harvesting of pepper begins when one or two berries in the spike turn yellow. The spikes are nipped of by hand and collected in bags (Fig.1). Normally, single pole bamboo/aluminium ladder is used as a support for climbing while harvesting. If the berries are allowed to over ripe, there is heavy loss due to berry drop and damage by birds. Spikes which are fallen on to the ground is collected separately, cleaned and then pooled to the general lot.

Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity required at harvest for processing into different pepper products is given in Table 1.

Table 1. Optimum maturity at harvest for different pepper products

Product	Stage maturity at harvest
Canned pepper	4-5 months
Dehydrated green pepper	10-15 days before maturity
Oleoresin and essential oil	15-20 days before maturity
Black pepper	Fully mature and 1-2 berries start turning from yellow to red in each spike
Pepper powder	Fully mature with maximum starch
White pepper	Fully ripe

Post Harvest Processing

Post harvest processing operations followed for black pepper involves threshing, blanching, drying, cleaning, grading and packaging. During processing care should be taken to maintain the quality during each step of operation.

Threshing

The berries are separated from the spike traditionally by trampling with human legs. This operation is crude, tedious and unhygienic. Chances of extraneous matter, soil particles and filth contaminating the produce are also high. Mechanical threshers with capacities varying from 50 kg/h to 2500 kg//h are available which can thresh quickly and provide cleaner products (Fig. 2). Considering the shortage of human labour mechanical threshing can be popularized at cluster level.

Blanching

The quality of the black pepper obtained can be improved by a simple treatment of dipping the harvested green berries, taken in a perforated vessel, in boiling water for a minute before drying. This processing technique has several advantages**:**

- Uniform coloured black pepper is obtained after drying.
- Pepper can be dried in 3-4 days as against 5-6 days required when following the traditional practice
- Removes the extraneous impurities like dust and reduces the microbial load of the berries.

Drying

Freshly harvested green pepper has a moisture content of about 65 to 70% at harvest, which should be brought down to safe level of 10% by adequate drying. The green colour of matured pepper is due to the presence of chlorophyll pigment. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on clean dry concrete floor / bamboo mats/ PVC sheets and dried under sun for 3-5 days to bring the moisture content below 10%. The average dry recovery varies between 33-37% depending on the varieties and cultivars.

Cleaning and grading

The dried black pepper has extraneous matter like dust, spent spikes, pinheads, stones, soil particles etc. mixed with it. Cleaning and grading are basic operations that enhance the value of the produce and help to get higher returns. Cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such units consist of a fan/ blower and a feeding assembly. The fan is placed at the rear end of the hopper. Cleaning is achieved by feeding the material through the hopper into a stream of air blowing in perpendicular direction. The heavier fractions (dust, immature berries, pin heads and spent spikes) are blown away.

Grading of black pepper is done by using sieves (3, 3.5, 3.8 and 4.8 mm etc.) and sifting black pepper into different grades based on size.

Packaging

Organically grown black pepper should be packaged separately and labelled. Mixing different types of pepper is not good from a commercial point of view. Eco friendly packaging materials such as clean gunny bags or paper bags may be adopted and the use of polythene bags may be minimized. Recyclable/ reusable packaging materials shall be used wherever possible.

Storage

Black pepper is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity may result in mould and insect infestation. Before storage, black pepper has to be dried to less than 10% moisture content. The graded produce is bulk packaged separately in woven polypropylene bags or jute bags provided with food grade poly ethylene liners or in or multi-layer paper bags. The bags are arranged one over the other on plastic/wooden pallets after laying polypropylene sheets on the floor to reduce the ingress of moisture into the produce.

Cardamom

Cardamom plants start bearing two or three years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120-135 days after its formation. Harvesting period commences from June-July and continues till January-February in Kerala and Tamil Nadu. While in Karnataka, harvesting begins in August and prolongs till December-January. Usually harvesting is done at an interval of 15-30 days.

The capsules are harvested when they attain physiological maturity, which is indicated by dark green colour of rind and black coloured seeds. Harvesting of ripened capsules is avoided as it leads to the loss of green colour and also causes splitting of capsules during curing process. Immature capsules on processing yields uneven sized shriveled and undesirably coloured produce. When a cardamom capsule is fully matured it can be easily removed from the stem of the plant without too much force. The harvester should start harvesting at the base of each stem and move up the stem, taking off any capsules that easily fall off without pulling. The capsules that do not fall off easily should be left on the plant to ripen.

Post Harvest Processing

Freshly harvested capsules are subjected to post harvest operations like cleaning, alkali treatment, drying, destalking, grading, packaging and storage.

Cleaning

Harvested capsules are washed in water to remove the soil particles and other dirt adhering to it and this process helps to get good quality finished product.

Pre-treatment

The fresh cardamom capsules are soaked in a solution of sodium bicarbonate (2-5%) for ten minutes to help retain the green colour. A 2% solution of sodium bicarbonate is prepared by dissolving 20 g of sodium bicarbonate in 1 litre of water. The capsules are removed from water and are spread on wire net trays of the drier.

Drying

Drying/curing of cardamom is the process by which moisture content of freshly harvested capsules is reduced from 80-85% to 10% through indirect heating. If the drying period is too long, mould can start to grow on the cardamom. There are several methods available to dry cardamom for the small scale processors, depending upon the size of the business and the local weather conditions. Each method has different advantages and disadvantages:

Cardamom is dried by adopting two methods:

1. Natural (Sun drying)
2. Artificial drying

Natural (Sun drying)

Freshly harvested capsules are directly dried under sun for a period of five to six days or more depending on the availability and duration of sunlight. Natural drying does not retain green colour of capsules and also leads to splitting of the capsules. During cloudy and rainy weather conditions, proper drying of capsules cannot be accomplished and hence the quality of the capsules deteriorates. In general, sun dried capsules are not preferred for export. Sun drying is commonly practiced in some parts of Karnataka.

Artificial drying

It is one of the best methods of drying by which high quality green cardamom can be obtained. A traditional firewood based curing house consists of a furnace for burning the wood, flue pipes for conveying the hot air and drying racks for stacking the trays. A drying chamber with dimensions of 4.5 m in length and breadth is sufficient for a plantation, which has a production capacity of 2 tonnes of fresh cardamom. In general, 3-4 kg of firewood is consumed for drying 1 kg of fresh cardamom.

The capsules are evenly spread as a single layer on the trays. After staking the trays on the racks in the drying chamber, the curing room is closed. Hot air generated by burning firewood in the furnace is circulated through the flue pipes, which are placed few centimeters above the floor. This process enhances the room temperature to 45-55°C, which is maintained for a period of 3-4 hours. During this period, the capsules sweat and give off the moisture. The drying process is facilitated by opening the ventilators for sweeping out the water vapour generated from the drying capsules. Exhaust fans are also used for the speedy removal of moisture. After complete removal of water vapour, the ventilators are closed and the temperature inside the chamber is again maintained at 45-55ºC for a period of 18-24 hours. In the final stage of curing process, the temperature is further raised to 60-65°C for another 1-2 hours. The temperature is raised to hasten the cleaning process by which debris like stalks attached to the capsules can be removed easily. Temperature inside the curing chamber is maintained around 65°C to avoid splitting of the capsules and also to prevent the loss of volatile oil. Under these conditions, it is possible to obtain high quality green cardamom in about 24-30 hours.

Efficient and highly automated cardamom dryers have been developed and being widely used with alternative sources of fuels such as kerosene, Liquid Petroleum Gas (LPG) and diesel or with combination of fuels. Such kind of improved systems have the advantage of retaining high quality of produce with respect to colour and duration of curing is also substantially reduced to 16-18 hours.

Polishing and grading

The dried capsules are rubbed on wire mesh to remove the stalk, dried portion of flower from the capsules and then graded according to size by passing through sieves of sizes of 7, 6.5, 6 mm etc. The graded produce is stored in polythene lined gunny bags to retain the green colour during storage.

Dried capsules are polished either manually or with the help of machines. Polishing is carried out by rubbing the dried capsules in hot state against a hard surface. The polished produce is subsequently graded based on the quality parameters such as colour, weight per volume, size and percentage of empties, malformed, shriveled and immature capsules.

After grading, cardamom capsules are stored at a moisture content of less than 10% to retain the original parrot green colour and to prevent mold growth. Use of 300 gauge black polythene lined gunny bags improves efficiency of storage. It is advisable to store the dried cardamom in wooden boxes at room temperature, preferably in the curing houses.

Turmeric

Well managed turmeric crop is ready for harvest in seven to nine months depending on the variety and time of sowing. The crop is generally harvested during January to March. On maturity, the leaves turn dry and are light brown to yellowish in colour. In Kerala, turmeric is grown in raised beds prepared either manually or by using a tractor with broad bed former (Fig. 3). Harvesting of the matured crop is done either manually or by using a tractor depending upon how the beds were formed. In case of manual harvesting, the land is ploughed, the clumps are carefully lifted with spade and the rhizomes are gathered by hand picking. Harvesting with a tractor attached to a turmeric harvester is followed when the raised beds are taken using a tractor. The harvested rhizomes are collected manually and all the extraneous matter adhering to them is cleared.

Post Harvest Processing

The harvested turmeric rhizomes before entering into the market is converted into a stable commodity through a number of post harvest processing operations like boiling, drying and polishing. Boiling of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter takes a little longer to cook. The dry recovery of the different turmeric varieties vary widely ranging from 19 to 23%.

Boiling

Boiling is the first post harvest operation to be performed at the farm level which involves cooking of fresh rhizomes in water until soft before drying. Boiling destroys the vitality of fresh rhizomes, avoids the raw odour, reduces the drying time and yields uniformly coloured product.

In the traditional method, a vessel made of galvanized iron sheet is used for turmeric boiling. Boiling of turmeric rhizomes is carried out till froth forms and white fumes come out of the pan with a characteristic odour. Boiling is considered complete when a pointed stick can penetrate easily in to the rhizomes with slight pressure. The other indications of the completion of boiling process are softness and easy breaking of rhizomes when pressed between the fore finger and thumb and a yellow interior instead of red one. An effective cooking time of 45 to 60 minutes for fingers and 90 minutes for mother rhizomes is considered essential. Overcooking and under cooking are found to affect the quality of the rhizome.

Improved turmeric boiler using steam boiling technique is followed when large quantities of turmeric are to be cured. The Tamil Nadu Agricultural University (TNAU) model of improved steam boiler for turmeric consists of a trough, inner perforated drums and a lid (Fig. 4). The outer drum is made of 18 SWG thick mild steel to a size of 122 x 122 x 55 cm. A lid is provided with hooks for easy lifting and also provided with an inspection door. For easy draining and cleaning, an outlet is placed at the bottom of the drum. Four numbers of inner drums of 48 x 48 x 45 cm size are provided in the outer drum. The capacity of four inner drum is 100 kg. The inner drums are provided with a leg for a height of 10 cm, so that the rhizomes will not come in contact with water filled for about 6-8 cm depth in the outer drum. The outer drum is placed with more than half of its depth below the ground level by digging a pit, which serves as a furnace. This furnace is provided with two openings, one for feeding the fuel and the other one for removing the ash and unburnt.

After placing the turmeric boiler in the furnace, about 75 litres of water is added (6-8 cm depth). About 55-70 kg of well washed rhizome is taken in each inner drum and placed in the boiler and the lid is placed in position. Using the available agricultural waste materials, mostly, the turmeric leaves, fire is put in the furnace. During the boiling process, it takes about 25 minutes to produce steam and boil the initial batch of rhizomes and 10-15 minutes for the subsequent batches. Through the inspection door, the stage of boiling of the rhizome is assessed by pressing the rhizomes with a hard pin / needle.

Using a long pole, the lid is removed and the inner drums are lifted one by one. For the next batch, about 20 litres of water is added to the outer drum, depending on the water lost by evaporation. The next batch of rhizomes is loaded in all the drums and heating is continued. At the end of the boiling process, all the drums need to be cleaned free of mud and soil to avoid damage and enhance the life of the gadget. The capacity of the boiler is about 100 kg per batch and the fuel requirement is 70-75 kg of agricultural waste materials. Turmeric boiling units of capacity 1 tonne/batch is also available and is used in regions where turmeric is grown extensively.

Drying

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor. A thin 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 10-12 days for the rhizome to dry completely. The bulbs and fingers are dried separately, the former takes more time to dry. Turmeric should be dried on clean surface to ensure that the product does not get contaminated by extraneous matter. Care should be taken to avoid mold growth on the rhizomes. Rhizomes are turned intermittently to ensure uniformity in drying. The yield of the dry product varies from 20-25% depending upon the variety and the location where the crop is grown. The starch gelatinized during boiling shrink and during the drying process intercellular spaces increase, enhancing water diffusion and reducing the drying time. For improved drying, the rhizomes can also be dried in a solar drier (Fig. 6)

Slicing and drying

In this practice, the turmeric rhizomes are mechanically sliced using a mechanical slicer having a capacity of 50 -100 kg/h and then dried mechanically in a mechanical drier or in a solar tunnel drier. In case of mechanical drier, it is ensured that drying is completed in one hour.

Polishing and colouring

Dried turmeric has poor appearance and rough dull outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing. Polishing is done till the recommended polish of 7-8% is achieved. Usually 5 to 8% of the weight of turmeric is the polishing wastage during full polishing and 2 to 3% during half polishing. Polishing of dried turmeric also helps in removing the wrinkles.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. Manual polishing gives rough appearance and dull colour to the dried rhizome. Polishing is done by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal screen. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against each other as they roll inside the drum. The turmeric is also polished in power operated drums (Fig.7). Large scale polishing units with capacity to polish 500 to 1000 kg per batch is used for polishing turmeric rhizomes at commercial units. It takes about 45-60 minutes per batch and about 4% is wasted as dust. The colour of the processed turmeric influences the price of the produce. Hence to obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

Cleaning, grading, packing, and storage

Although Indian turmeric is considered to be the best in the world, about 90 % of the total produce is consumed internally and only a small portion of the production is exported. Turmeric of commerce is described in three ways:

Fingers: These are the lateral branches or secondary 'daughter' rhizomes which are detached from the central rhizome before curing. Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.

Bulbs: These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers.

Splits: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.

Turmeric being a natural produce, is bound to gather contaminants during various stages of processing. The spice is also cleaned to remove such foreign materials. A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter. Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light. The stores should be clean and free from infestation of pests and harborage of rodents. It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests.

Ginger

Harvesting of the crop for vegetable purpose starts from the sixth month of planting based on the demand and price of the produce. However, for making dry ginger, the matured rhizomes are harvested after eight months i.e. when the leaves turn yellow and start drying. Irrigation is stopped one month before harvest and the rhizome clumps are lifted carefully with a spade or digging fork. The dry leaves, roots and soil adhering on the rhizomes are manually separated. The mother rhizome has equal market value as that of freshly harvested ginger because of the large size. Late harvest is also practiced, as the crop does not deteriorate by leaving it for some months underground. In India, domestic market prefers fresh green ginger for culinary use while two types of dried ginger i.e. bleached and unbleached are also produced for export purpose.

The most important criteria in assessing the suitability of ginger rhizomes for particular processing purposes are the fiber content, volatile-oil content and the pungency level. The relative abundance of these three components in the fresh rhizome is governed by its state of maturity at harvest. Tender rhizomes lifted at the beginning of the harvesting season, about 5 to 7 months after planting, are preferred for the manufacture of preserved ginger since the fiber content is negligible and the pungency is mild. As the season progresses, the relative abundance of the volatile oil, the pungent constituents and the fiber increases. At about eight months after planting, the volatile oil and pungent principle contents reach a maximum and thereafter their relative abundance falls as the fiber content continues to increase. In India, the volatile oil content of ginger has been reported to be at maximum between 215 and 260 days after planting.

Post Harvest Processing

Processing of ginger to produce dry ginger basically involves two stages - peeling of the ginger rhizomes to remove the outer skin and sun drying to a safe moisture level.

Peeling

Peeling serves to remove the scaly epidermis and facilitate drying. Peeling of fully matured rhizomes, is done by scrapping with bamboo splits having pointed ends to remove the outer skin and to accelerate the drying process. Deep scraping with knifes should be avoided to prevent the damage of oil bearing cells which are present just below the outer skin. Excessive peeling will result in the reduction of essential oil content of the dried produce. The peeled rhizomes are washed before drying. The dry ginger so obtained is valued for its aroma, flavour and pungency.

Indian dried gingers are usually rough peeled when compared to Jamaican gingers, which are clean peeled. The rhizomes are peeled only on the flat sides and much of the skin in between the fingers remains intact. The dry ginger so produced is known as the rough peeled or unbleached ginger and bulk of the ginger produced in Kerala are of this quality. Sometimes Indian gingers are exported unpeeled.

Drying

The moisture content of ginger after harvest is about 80-82 % which is brought down to 10% for its safe storage. Traditionally ginger is sun dried in a single layer in open yard which takes 7 to10 days for complete drying. The sun dried ginger is brown in colour, with irregular wrinkled surface and when broken, shows a dark brownish colour. The yield of dry ginger is 19-23 % of fresh ginger depending on the variety and climatic zone.

Polishing

Polishing of dried ginger is done to remove the wrinkles developed during drying process. In traditional method, the dried ginger is rubbed against hard surface and this helps to remove the dry scales of the skin attached to the surface.

Bleached ginger

Bleached ginger is produced by dipping scrapped fresh ginger in a slurry of slaked lime, $Ca(OH)_2$, (1 kg of slaked lime/120 kg of water) followed by sun drying. As the water adhering to the rhizomes dry, the ginger is again dipped in the slurry. This process is repeated until the rhizomes become uniformly white in colour. Dry ginger can also be bleached by the similar process. Liming gives ginger a better appearance and less susceptibility to the attack of insect pests during storage and shipping.

Cleaning and grading

Cleanliness of spices has been the major concern of the importing countries. Once the ginger is cleaned and dried it is graded manually. For ginger, the grading takes into consideration the size of the rhizome, its colour, shape, extraneous matter, the presence of light pieces and the extend of residual lime (in the case of bleached ginger).

Packaging and Storage

Dry ginger, packed in gunny bag, is highly susceptible to insect infestation during warehouse storage. It is preferable to use polythene laminated gunny bags for packaging dried ginger. Dried ginger should be stored ensuring protection from dampness. Dunnage made of PVC/wooden crates should be used to stack the packaged bags to prevent moisture ingress from the floor. Care should be taken to stack the packed bags 50 to 60 cm away from the walls. Insects, rodents, and other animals should be effectively prevented from getting access to the premises where gingers is stored. Prolonged storage of ginger would result in deterioration of its aroma, flavour and pungency.

Organic ginger has to be packaged in reusable and biodegradable packaging material whenever possible and the material should not contaminate the organic food. Organically produced ginger should be labeled accordingly. Packaging materials, storage containers or bins that are contaminated with fungicides, preservatives or fumigants are prohibited to be used for packaging ginger as they are likely to compromise the organic integrity of product.

Chillies

Chilli is the dried ripe fruit of genus "*capsicum*" which is also called *red pepper* and it constitutes an important commercial crop used as a condiment, culinary supplement or as a vegetable. Among the chilli consumed in India, dried chilli contributes the major share. The Indian *sannam* variety of chilli is well known the world over. It is cultivated in Andhra Pradesh and part of Tamil Nadu. The main marketing season for chilli in India is February-March.

Post Harvest Processing

Harvesting of chillies is done when the pods are well ripened and partially withered in the plant itself. Immediately after harvesting of fresh fruits, they are heaped indoors for 2 or 3 days, so that the partially ripe fruits, if any, are ripen fully and whole produce develops a uniform red colour. The best temperature for ripening is 22-25°C and direct sun light should be avoided which can cause development of white patches.

Drying

The drying of chilli is done by spreading the fruits on dry ground or concrete floor under sun. In case of cement floor, drying takes 5-6 days for the reduction of moisture content from 65-70% to 10%, while in mud floor it takes 3-4 days during sunny days. In case of cloudy weather and intermittent rains, damages as high as 50% are reported. Such unfavourable conditions also lead to discolouration with white spots over the surface of final product. Loss of glossiness and pungency are also noticed. In view of its direct exposure to environment, dirt may also get deposited on the chilli besides; this method involves excessive handling and irrecoverable shatter loss.

Sorting

At the final stage of drying, the discoloured, spoiled and other damaged ones are manually sorted based on the eye judgment and experience. These sorted ones are collected and separated. This amount to 4-5 quintals of dry chilli obtained in a crop area of one hectare. This works out to about 20 to 25% of the final produce. This reject is sold separately at a much lower price. During the sorting process itself the dried chilli fruits will be windrowed for easy collection and packaging.

Destalking

Destalking of dried chilli pod is done after drying and before cold storage/marketing. The export lots are preferred without stalk as required by the buyers. Contract women labour are engaged for destalking. Normally a woman can destalk 12-15 kg of chili. The chilli stalks after removal has no commercial value and hence burnt or composted.

Collection and heaping

The dried chilli are collected from the drying yard in polywoven bags and transported to the packing yard and heaped. Being a high volume material, during heaping, compaction is done to accommodate more quantity in less space. To prevent absorption of moisture from the atmosphere, the heap is also fully covered with polythene sheets till packed in bags and transported to the market.

Packaging

The well-dried chilli pods are packed in gunny bags for transporting to the market. Normally the gunny bags will hold about 30 kg of dried chilli and to accommodate more quantity of chilli in each bag, the material being packed is compacted. For compacting the produce, manually it is rammed in the gunny bag by a labour. By this, about 50 kg of dry chilli is packaged in a gunny bag. This helps to reduce bulk and in easy transportation.

Cold Storage

To maintain the quality and preserve the colour of dried chilli packed in gunny bags is stored under cold storage. More than 60 cold storage godowns are available in and around Guntur, Andhra Pradesh state and also few units available in Tamil Nadu state. Normally the storage will be for the period during February to December. Storage is done at a temperature of 4-6°C and the relative humidity ranges 60 to 80%. The cold storages are normally with a plinth area of 1000 to 2000 m^2 with 4-6 floors. Each floor is to a height of 3-4 m and the evaporators are placed in the each floor for uniform distribution of temperature. The bottom of each floor is made of wooden planks and only steps are used to reach the various levels of the storage godown. The walls and roof of the cold storage godowns are constructed with brick and concrete. The latest ones are constructed with polyurethane foam lined with metal sheet with improved insulation.

References:

Agarwal Y.C, Ashwini Hiran and A.S Galundia ,1987. Ginger peeling machine parameters, *Agricultural Mechanization in Asia, Africa and Latin America, 18(2):57-62.*

Amaladhas H.P, Shinoj Subramanian, M. Balakrishnan, R. Viswanathan and V.V Sreenarayanan, 2004. Performance evaluation of a cleaner cum- grader for black pepper, *Journal of Plantation crops*. 32(1) 32-36.

Amala dhas H.P, P. Rajesh and Shinoj Subramanian, 2002. Get better quality mace by blanching, Spice India, 15(2), 8-10.

Bhalerao S.D, 1993. New Developments in the on farm processing of red Chillies, *Proceedings of the National seminar held at RRL, Trivandrum 13-14 May organized by Indian Society for Spices Research and Spices Board,* pp :50-52.

Joy C.M, George Peter Pittappillil and K.P Jose , 2000. Quality improvement of nutmeg using solar tunnel dryer, Journal of Plantation crops, 28(2),138-143.

Kachru R. P and P.K Srivastava, 1988. Post Harvest Technology of ginger. *CARDAMOM*, 21(5) , pp : 49-57.

Kachru R. P and P.K Srivastava, 1991. Processing of Turmeric, *Spice India* , 4(9): 2-6.

Kachru K.P and R.K Gupta 1993. Drying of spices- Status and challenges, *Proceedings of the National seminar held at RRL, Trivandrum 13-14 May organized by Indian Society for Spices Research and Spices Board,* pp :50-52.

Korikanthimath V.S, 1993. Harvesting and on-farm processing of cardamom, *Proceedings of the National seminar held at RRL, Trivandrum 13-14 May organized by Indian Society for Spices Research and Spices Board,* pp :50-52.

Patil R.T, 1987. Cardamom Processing in South India. *Agricultural Mechanization in Asia, Africaa and Latin America,* 18(2):55-58

Sreenarayanan V.V, B.Chempakam and R. Viswanathan, 2003. Final Report of the Research Project funded under NATP-CGP on Value addition and Quality enhancement of selected spices. Department of Agricultural Processing, TNAU Coimbatore. pp:3.

Value Addition in Spices

E. Jayashree
ICAR-Indian Institute of Spices Research, Marikunnu P.O, Kozhikode 673012

Spices are high value export oriented crops extensively used for flavoring food and beverages, medicines, cosmetics, perfumery etc. Spices constitute a significant and indispensable segment of culinary art and essentially add flavour, color and taste to the food preparations. The farm level processing operations are of utmost importance for value addition and product diversification of spices. It is essential that various operations like washing, threshing, blanching, drying, cleaning, grading, storing and packaging ensure proper conservation of the basic qualities like aroma, flavour, pungency, colour etc. Each of these operations enhances the quality of the produce and the value of the spice.

India is the largest producer, consumer and exporter of spices in the world. India produces more than 65 spices in different varieties out of the 109 Spices listed by International Standards Organisation (ISO). India produces around 5.8 million tonnes of spices annually (2012-13), of this about 10% of the total produce is exported to over 150 countries. The USA, Europe, Australia, Japan, the Middle East and Oceanic countries are the major importers of Indian spices. The estimated world trade in spices is 1.05 million tonnes valued at 2750 million US $, out of which India has a significant share of 48% in quantity and 43% in value.

1. Black Pepper

Pepper *(Piper nigrum)* takes about 180 to 230 days after flowering to reach full maturity. Harvesting is generally done when the berries are fully mature and few starts turning from yellow to red in each spike. The stage of maturity at harvest varies depending on the final value added product to be prepared from pepper. Generally black pepper is harvested at full maturity and the berries are separated either manually or by using mechanical threshers. The separated berries are dried on clean concrete floors for 5days to reduce the moisture content from about 70% to less than 10%. The recovery varies from 33-37% and the dried berries are cleaned to remove the extraneous matters like broken spikes, pinheads, stones, soil particles etc. and finally packaged in jute gunny bags or woven polypropylene bags and stored.

Value added products of pepper : Variety of product have been made from pepper and are classified as (I) Green pepper based products (II) Black pepper and white pepper based products (III) Pepper by- products.

1. Green pepper based products

i. Canned green pepper: The despiked and cleaned berries are immersed in 2% hot brine containing 0.2% citric acid exhausted at 80°C, sealed properly and processed in boiling water for

20 minutes. Canned pepper is cooled immediately in a stream of running cold water. The pepper harvested one month before maturity is ideal for the manufacture of canned green pepper

ii. Green pepper in brine: Freshly harvested green berries or spikes as such are used for preparing pepper in brine. The berries are washed and the cleaned berries are stored in brine solution having a concentration of 17 ± 2% salt with added vinegar of around 0.6 ± 2%. Pepper is washed three times in a period of 45 days at an interval of 20, 20 and 15 days, respectively and each time the brine solution is changed. The pepper is then packed in high density poly ethylene (HDPE) food grade cans with sufficient quantity of freshly prepared brine solution of the same concentration just sufficient to immerse the pepper. Major applications of green pepper in brine are in making sauces, meat processing industries and in the food service sector.

iii. Dehydrated green pepper: Slightly immature green pepper is preferred for producing dehydrated green pepper. Freshly harvested cleaned pepper berries are subjected to blanching in boiling water for 15 minutes till the enzymes responsible for blackening the pepper are inactivated and polyphenols washed out of the berries. The berries are cooled immediately and dried in a cabinet drier at 70°C. Boiling time depends on the maturity of the berries.

vi. Frozen green pepper: Frozen green pepper is considered far superior to green pepper in brine or dehydrated green pepper because it has better flavour, colour, texture and natural appearance. It is packed in poly pouches and hence the cost is much less compared to cans and containers. Though freezing is expensive, it is gaining popularity because of its superiority in every respect.

vii. ***Freeze dried green pepper:*** The moisture content of fresh tender green pepper is removed by freeze drying the berries at -30°C to -40°C under high vacuum. As a result of this, a product with its natural colour, texture and of far superior quality to those of sun dried, solar dried or mechanically dehydrated green pepper is obtained. It is very light much lighter than frozen green pepper, since its moisture is reduced to 2-4%. The demand for freeze dried green pepper is growing and is likely to go up in due course.

viii. ***Green pepper pickle:*** Green pepper pickle is popular in many states notably in Kerala, Karnataka, Tamil Nadu, Gujarat and Maharashtra etc. People relish it with rice as an appetizer. When mixed with shredded fresh ginger, it becomes more tasty and piquant.

ix. ***Mixed green pepper pickle:*** Green pepper berries are mixed with lime pickles, mango pickles, mixed cauliflower and carrot pickles, brinjal pickles, bitter gourd pickles with or without green chillies and sliced fresh ginger. They are quite popular but however their preparation is mostly limited to domestic scale.

x. ***Green pepper sauce:*** It is made from selected green pepper berries, which are first ground pure and then blended with vinegar, salt, sugar and other ingredients. It has natural flavour and is often used as a dip for chips or fries.

xi. ***Green pepper flavoured products:*** Green pepper is advantageously used in soups, rasam etc. Green pepper in *Biriyani, Rice Pulao* and *Upma* is very much liked since its attractive colours make the product more attractive. The berries give the exotic taste to Westerners while eating it in conjunction with other products. Green pepper is also used in garnishing of salads and other food.

2. Black pepper and white pepper based products

i. ***Whole black pepper:*** Fully mature green pepper is dried under sun for 5 days to obtain whole black pepper. In the modern spice processing unit, black pepper is first passed through a cleaning cum grading unit which consists of a specific gravity separator/destoner for removal of stones, an aspirator for sucking and removal of light impurities like the pin heads, husk, light berries, dust etc. and a multiple sieve grader for grading the black pepper. The pepper is then passed through a spiral separator to remove flat impurities like broken spikes etc. from pepper and passed through a magnetic separator for the removal of metallic impurities. The cleaned pepper is graded in to different sizes as 4.75 mm, 4.25 mm, 4.0 mm, 3.25 mm etc., and packaged in bulk or consumer packages for domestic or outside market.

ii. ***Sterilized black pepper:*** The cleaned black pepper is subjected to sterilization to ensure high quality, microbial contamination free, clean and dried product. In continuous steam sterilization method, the spice is subjected to a rapid flow of superheated steam for a predetermined period of time followed by drying, rehumidification and packaging. Microbial levels as well as the enzyme activity are considerably reduced to low levels. In countries where the sterilization by chemical method is not permitted, steam sterilization is the best alternative.

The chemical sterilization involves the use of permitted chemicals like ethylene oxide for destroying microbes. Effectiveness of sterilization depends on the moisture content of the pepper, concentration of the gas, temperature and time of contact.

iii. ***Ground pepper:*** Ground pepper is obtained by grinding cleaned black pepper without adding any foreign matter. Grinding is accomplished by employing equipments like hammer mill, pin mill or plate mill. The ground product is further sieved and materials possessing the required size are packed. The overflow is sent back to the grinding zone for further size reduction.

iv. ***Cryoground pepper powder:*** In the conventional grinding of spices, the mill and the product temperature can rise to as high as 90°C and at high temperatures there is considerable loss of volatile oil. Cryogenic grinding overcomes this problem and helps in retaining more volatile oils besides reducing oxidation, improving fineness and posing minimum distortion in the natural composition of powder. The usual practice during the cryogrindng is to inject liquid nitrogen (-80°C) into the grinding zone. A temperature controller maintains the desired product temperature by suitably adjusting the nitrogen flow rate. The exhausted gas is recirculated for precooling of the spice.

v. ***Pepper oil:*** The characteristic aroma of black pepper is due to the presence of volatile oil which ranges from 2-5% and can be recovered by steam or hot water distillation. Industrial process for the recovery of essential oil involves flaking of the black pepper using roller mills or grinding into coarse powder and distilling it in a stainless steel extractor. The steam comes in contact with the ground pepper particles and vaporizes the oil present in the oil cells. On cooling, the oil is separated from water. It is observed that slightly immature pepper will have more oil.

vi. ***Oleoresin:*** Oleoresins is the concentrated product of all the flavour components (aroma, taste, pungency and related sensory factors) obtained by cold extraction of ground pepper using solvents like hexane, ethanol, acetone, ethyl acetate etc. Pepper is flaked to a thickness of 1 to 1.5 mm and packed in stainless steel extractors for extraction with the organic solvent. Normally, solid to solvent ratio of 1:3 is employed and the recovery is 10-13%.

vii. ***Piperine:*** Piperine content ranges from 3-6%. The alkaloid piperine is the major constituent responsible for the biting taste of black pepper.

viii. ***Supercritical Fluid Extraction (SFC):*** When a gas is compressed and maintained below its critical temperature and critical pressure, it becomes a super critical fluid. The solvent free extraction of essential oils and oleoresins by supercritical fluid extraction technology has shown promising results. Though there are many super critical fluids available, carbon di oxide is the most widely accepted supercritical fluid. The critical temperature and pressure beyond which carbon di oxide behaves as super critical fluid are 31.3°C and 73.8 bar pressure respectively.

ix. Microencapsulated spice flavor: Microencapsulation is the technique by which the flavour material is entrapped in a solid matrix and is ready for release as and when required. Encapsulation is achieved mostly by spray drying. In the production of spray dried spices, the essential oils and or oleoresins are dispersed in the edible gum solution, generally gum acacia or gelatin, spray dried and then blended with dry base such as salt or dextrose. As water evaporates from the spray dried particles, the gum forms a protective film around each particle of extractive. The protective capsule prevents the spice extractive from evaporating and from being exposed to oxygen.

x. White pepper: White pepper is the white inner corn obtained after removing the outer skin or pericarp of pepper berries. The traditional method of preparation of white pepper is by retting. If running water is not available, the alternative is to use fermentation tanks wherein the water is changed every day for 7-10 days. Retting converts only ripe and fully mature green berries to white pepper. Conversion of harvested berries to white pepper gives a recovery of 22 to 27%.

White pepper is preferred over black pepper in light coloured preparations such as sauces, cream soups etc. where dark coloured particles are undesirable. It imparts modified natural flavour to food stuff.

xi. White pepper powder: White pepper powder is processed in the same way as the black pepper powder, except the starting material is white pepper. White pepper powder can also be produced from black pepper by selective grinding followed by sieving. Before the pepper is subjected to grinding, it is conditioned by adjusting the moisture content.

3. Other products

Many products, in which pepper is a major ingredient, have been developed such as lemon pepper, garlic pepper, sauces and marinades that have pepper as the main component.

i. *Spice mixtures and blends: C*urry powders and spice blends for various culinary uses
ii. *Pepper flavoured products:* Products such as pepper mayonnaise, pepper cookies, , pepper tofu etc.
iii. *Pepper extracts:* pepper candies, pepper perfumes etc.

2. Cardamom

Cardamom *(Elettaria cardamomum)* plants take about two years to bear capsules and about 3 months after flowering for fruit maturity. Harvesting of cardamom is taken up at a time when the seeds inside the capsules have become black and the pericarp is still green in colour.

The harvested capsules are washed in water to remove dust and soil particles. The capsules are then treated with 2% sodium carbonate solution for 10 minutes and spread on wire net trays of the flue type kiln drier. The heat produced by burning the firewood in iron kiln is passed through pipes into the drying chamber. They are initially dried at 50ºC for the first 4 h and heat is then reduced to 45ºC by opening ventilators and operating exhaust fans till the capsules are properly dried. Finally, the temperature is raised to 60ºC for an hour. The process of drying takes about 18-24 h for reducing the moisture content from 80% to 10%.The dried capsules are rubbed on wire mesh to remove the stalk, dried portion of flower from the capsules and then graded according to size by passing through sieves of sizes of 7, 6.5, 6 mm etc. The graded produce is stored in polythene lined gunny bags to retain the green colour during storage

Value added products of cardamom

i. Oleoresin: Solvent extraction of ground spice yields 10% oleoresin. Cardamom oleoresin is used for flavouring food after being dispersed in salt, flour etc.

ii. Essential oil: The essential oil of cardamom is extracted by steam distillation from the seeds of the fruit gathered just before they are ripe and the yield is 1-5 %. The main chemical components of cardamom oil are a-pinene, b-pinene, sabinene, myrcene, a-phellandrene, limonene, 1,8-cineole, y-terpinene, p-cymene, terpinolene, linalool, linalyl acetate, terpinen-4-oil, a-terpineol, a-terpineol acetate, citronellol, nerol, geraniol, methyl eugenol and trans-nerolidol. The cardamom oil is a precious ingredient in food preparations, perfumery, health foods, medicine and beverages. A good portion is consumed for chewing or as a masticatory item.

iii. Decorticated seeds / seed powder: Decorticated seeds command a lower price due to rapid loss of volatile oil during storage and transportation. Seed powder is marketed to a limited extent.

iv. Bleached cardamom: A proportion of the crop is bleached after sun drying by exposing the capsules to fumes obtained from burning sulphur to get uniform colour and appearance. Steeping capsules in a dilute solution of potassium meta bi sulphite solution induces a slight improvement in keeping quality.

3. Turmeric

Turmeric (*Curcuma longa*) is ready for harvest in about 7-9 months depending up on the variety, when the leaves of the plant turn yellow and starts drying. At the time of harvest the land is ploughed either manually or by using tractor mounted turmeric harvester and the clumps are carefully lifted with a spade and gathered by handpicking. The clumps are cleaned to remove mud, roots etc. and the fingers are separated from the bulbs (mother rhizomes). Curing of fingers and bulbs are done separately by cooking in boiling water for 45-60 min and 60-90 min respectively until the rhizomes are soft which can be tested by piercing a wooden needle. Steam boilers of varying capacities are available for curing of turmeric rhizomes which have the ease of operation and can cure large quantities in a day. The cooked fingers are sun dried by spreading the materials on clean drying floor which takes 10 to 12 days for reduction in moisture content from about 82% to 10 %. Dried turmeric rhizomes are polished in a mechanical polisher with capacities varying from 100 to 500 kg/batch for about 45-60 min to improve the colour and smoothen the rough hard outer surface. The loss due to polishing is about 5-10%. The cleaned and graded turmeric rhizomes are packaged in clean gunny bags.

Value added products from Turmeric

i. Turmeric Powder: Dried turmeric is powdered to a fine mesh-60 (250 microns) to be used in various end products. Turmeric rhizomes contain 4-6% of volatile oil and there is a great chance of losing the oil when powdered. Hence it is to be properly packed immediately after powdering.
ii. Turmeric oil: Dried rhizomes and leaves are used industrially to extract the volatile oil. Dried rhizomes contain 5-6% and leaves contain about 1-1.5% oil. It is generally extracted by steam distillation.
iii. Turmeric oleoresin: Turmeric rhizomes contain about 7-14% oleoresin. This can be extracted using organic solvents such as acetone, hexane, ethyl acetate etc. The major compound in the oleoresin is the colouring principle curcumin. It is used in food preparation and pharmaceutical products.
iv. Curcumin: The major colouring principle of turmeric is curcumin. The curcumin content in turmeric varieties vary from 3-9%. It is a mixture of three pigments, curcumin, demethoxy curcumin and bis-de methoxy curcumin. It is preferred in the food and pharmaceutical industry as a natural colourant.

4. Ginger

Ginger *(Zingiber officianale*) is used both as a fresh vegetable and as a dried spice. The crop is ready for harvest in about 8 months after planting when the leaves turn yellow and start drying up gradually. Harvesting is to be done from the 6^{th} month onwards when it is used as green ginger but for making dry ginger it is harvested at full maturity. The clumps are lifted carefully with spade or digging fork and the rhizomes are separated from the dried up leaves, roots and adhering soil. The clumps are broken to rhizomes of sufficient length followed by partial peeling to remove the outer skin. Peeling hastens the process of drying and maintains the epidermal cells of the rhizomes, which contains essential oil responsible for aroma of ginger. The peeled ginger with moisture content of about 82-84% is spread thinly on concrete floor and dried under sun for 10-12 days until the moisture content is reduced to 10%. The dry ginger so obtained is known as rough or unbleached ginger. The yield of dry ginger is 20% of fresh ginger depending on the variety and the location where it is grown. The dried ginger rhizomes are manually graded based on the external appearance and bulk packaged separately in jute or woven poly propylene bags.

Value added products from ginger

i. Ginger powder: Dried ginger is powdered to a fine mesh-60 (250 microns) to be used in various end products.
ii. Salted ginger: Fresh ginger (with relatively low fibre) harvested at 170 -180 days after planting can be used for preparing salted ginger. Tender rhizomes with portion of the pseudo

stem is washed thoroughly and soaked in 30% salt solution containing 1% citric acid. After 14 days it is ready for use and can be stored under refrigeration.

iii. Crude fibre: In fully matured ginger crude fibre varies from 3-8%. It is estimated by acid and alkali digestion of ginger powder and whatever remains is considered as fibre.

iv. Ginger oil: Dry ginger on distillation yields 1.5 to 2.5% volatile oil. The main constituent in the oil is zingiberene and contributes to the aroma of the oil.

v. Ginger oleoresin: Dry ginger powder on treating with organic solvents like acetone, alcohol, ethyl acetate etc. yield a viscous mass that attribute the total taste and smell of the spice. The major non volatile component of oleoresin is gingerol. The oleoresin content varies from 4 -10%.

vi. Others: Sweet and salty products can be prepared from fresh ginger like ginger candy, ginger paste, salted ginger, salted ginger, crystallized ginger etc.

5. Nutmeg

Nutmeg and mace are two different parts of the same fruit of the nutmeg tree, *Myristica fragrans*. The fruits are harvested when they split open on ripening. The harvested fruits are handpicked and washed in water to remove dirt and mud adhering to the outer pericarp. The mace which is the outer aril of the nutmeg is separated from the nut and the two spices are dried separately. The nut which is very rich is fat called the nutmeg butter is dried at a low temperature of about 45°C and takes about 5-6 days for drying. The drying is stopped when a rattling sound is heard on shaking the nut. While the mace is dried at a temperature of 55°C and takes about 6-7 h for complete drying.

Value added products from nutmeg

i. Nutmeg powder: Dried nutmeg is ground to fine powder to be used in various end products.

ii. Nutmeg oil: The essential oil from nutmeg is steam distilled and the oil percentage varies from 5-15%. The essential oil is highly sensitive to light and temperature and yields a colourless, pale yellow or pale green oil with characteristic odour of nutmeg.

iii. Nutmeg oleoresin: Nutmeg oleoresin is obtained by solvent extraction of spices. Oleoresins contain saturated volatile oil, fatty oil and other extractives soluble in the particular solvent. Nutmeg oleoresin is extracted with organic solvent and yields about 10-12% of oleoresin.

iv. Nutmeg butter: The fixed oil of nutmeg is known as nutmeg butter with a consistency of butter at ambient temperature. Nutmeg butter contains 25 to 40% fixed oil and can be obtained by pressing the crushed nuts between plates in the presence of steam or hot water.

v. Mace oleoresin: When extracted with petroleum ether mace yields 10 to 13% oleoresin.

vi. Mace oil: is obtained by steam distillation of dried aril and yields 4-17% oil. It is colourless liquid with characteristic odour and flavour. Mace oil is more expensive than nutmeg oil.

6. Cinnamon

Cinnamon (*Cinnamomum zeylanicum*) is obtained by drying the central part of the bark after the third year of planting. It is harvested from the branches which have attained greenish brown colour indicative of maturity and when the bark peels of easily. The shoots are cut for bark extraction and the rough outer layer is first scraped off with special knife. The scraped portion is polished with brass rod to facilitate easy peeling. A longitudinal slit is made from one end to the other end and the bark is peeled off. Pieces of removed bark are known as quills. The curled quills are placed inside one another to make compound quill and dried under shade to prevent warping. After 4-5days of drying, the quills are rolled on a board to tighten the fillings and then placed in subdued sunlight for further drying.

The Sri Lankan grading system divides cinnamon quills into four main groups based on the diameter. The best known grade of cinnamon is the quills. Quills are long compound rolls of cinnamon bark measuring more than 107 cm long. The small pieces of bark (5-20 cm long), left after preparing the quills are graded as quilling. Featherings are the very thin inner pieces of bark or twisted bark and the chips are trimmings of quills or the bark of coarser canes that are scraped off, instead of peeling. The bark that is scrapped off without removing the outer bark is known as unscrapped chips and that scrapped after removing the outer bark are scrapped chips.

Value added product from cinnamon

i. Cinnamon oleoresin: The dry cinnamon bark powder on treating with solvents like acetone, hexane, ethyl acetate yields a viscous mass that attribute to the total taste and aroma of cinnamon. The oleoresin content varies from 7-10%. The oleoresin is dispersed on sugar and salt and used for flavouring processed foods.
ii. Cinnamon bark oil: It is essentially extracted by the steam distillation of cinnamon and the oil percentage varies from 0.5 to 2.5%. The main constituent of this oil is cinnamaldehyde which is about 65% but other compounds like the eugenol, eugenyl acetate, ketones, esters and terpenes also impart characteristic odour and flavor to this oil. It is used in flavouring bakery foods, sauces, pickles, confectionary, soft drinks, dental and pharmaceutical preparations and in perfumery.
iii. Cinnamon leaf oil: Cinnamon leaf oil is produces by steam distillation of leaves yielding 0.5 to 0.7% oil. The major constituent is the eugenol (70-90%) while the cinnamaldehyde content is less than 5%. The oil is used in perfumery and flavouring and also as a source of eugenol.

7. Clove

Clove is the small, reddish brown unopened flower bud of the tropical evergreen tree *Syzygium aromaticum*. The trees begin to yield from 7-8 years after planting. Buds are harvested when the base of calyx has turned from green to pink in colour. If allowed to develop beyond this stage, the buds open, petals drop and an inferior quality spice is obtained on drying. Prior to drying, buds are removed from the stem by holding the cluster in one hand and pressing it against the palm of the other with a slight twisting movement. The clove buds and stems are piled separately for drying. Buds may be sorted to remove over-ripe cloves and fallen flowers. Immediately after the buds are separated from the clusters, partial shade drying is followed. In sunny weather, drying is completed in 4-5 days giving a bright coloured dried spice of attractive appearance. During drying, clove loses about two-third of its original fresh green weight. When properly dried, it will turn bright brown and does not bend when pressed. The dried cloves are sorted to remove mother of cloves and khoker cloves, bagged and stored in a dry place.

Value added product from clove

i. ***Clove bud oil***: Clove bud oil contains 14 to 20% essential oil, the principal component of which is the aromatic oil eugenol (85-89%) which is extracted by distillation. Clove bud oil is used for flavouring food and in perfumery.

ii. ***Clove steam oil***: Clove stem oil is obtained from dried peduncles and stem of clove buds. The eugenol content ranges from (90-95%) and possesses a coarser and woodier odour than the bud oil.

iii. ***Clove leaf oil***: Clove leaves on distillation yield 2-3% oil dark brown liquid which on rectification turns pale yellow and smells sweeter with a eugenol content of 80-85%.

iv. ***Clove oleoresin***:Clove oleoresin is prepared by cold extraction of crushed spices using organic solvent like acetone giving a recovery of 18-22%. The oleoresin is chiefly used in perfumery and used for flavouring when it is dispersed on salt, flour etc.

Conclusion

There is assured market for processed spice products like curry powders, oils and oleoresins. The world over demand for spices as nutraceuticals is showing an upward trend. Spices and its derivatives offer great scope under food related agriculture industries. Post harvest management of spices has great scope considering present International trade scenario. We expect a huge jump in the export of curry powders and other value added products of spices in the coming decade.

ICAR-All India Coordinated Research Project on Spices

K Nirmal Babu and Sharon Arvind
ICAR-Indian Institute of Spices Research, Marikunnu P.O, Kozhikode 673012

ICAR-All India Coordinated Research Project on Spices (AICRPS), the largest network of spice scientists in India has adopted multidisciplinary approach to develop over 150 improved spice varieties and location specific technologies ensuring food safe spice production. ICAR- AICRPS, located at ICAR-Indian Institute of Spices Research, Kozhikode, Kerala has 38 centers (19 regular centers, 11 co-opting centers and 8 voluntary centers) representing 14 agro-climatic regions in 24 states including North Eastern States and Tribal areas. AICRPS was initiated in 1971 as All India Spices and Cashew nut Improvement Project (AISCIP). In 1986 it has become a full-fledged coordinating unit for spices (major spices and seed spices) with its headquarters at Indian Institute of Spices Research, Kozhikode, Kerala. Presently, ICAR- AICRPS is working on 14 mandate crops viz., Black Pepper, Small Cardamom, Large Cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Coriander, Cumin, Fennel Fenugreek, Ajwain and Nigella. In addition to these crops, Research on saffron and Kalajeera (*Bunium persicum*) has been taken up through project mode funding. In each of the mandate crop there are several projects and each project of AICRPS is being carried out simultaneously in several centres. A total of 110 projects are being undertaken by AICRPS.

Mandates of the AICRPS are:

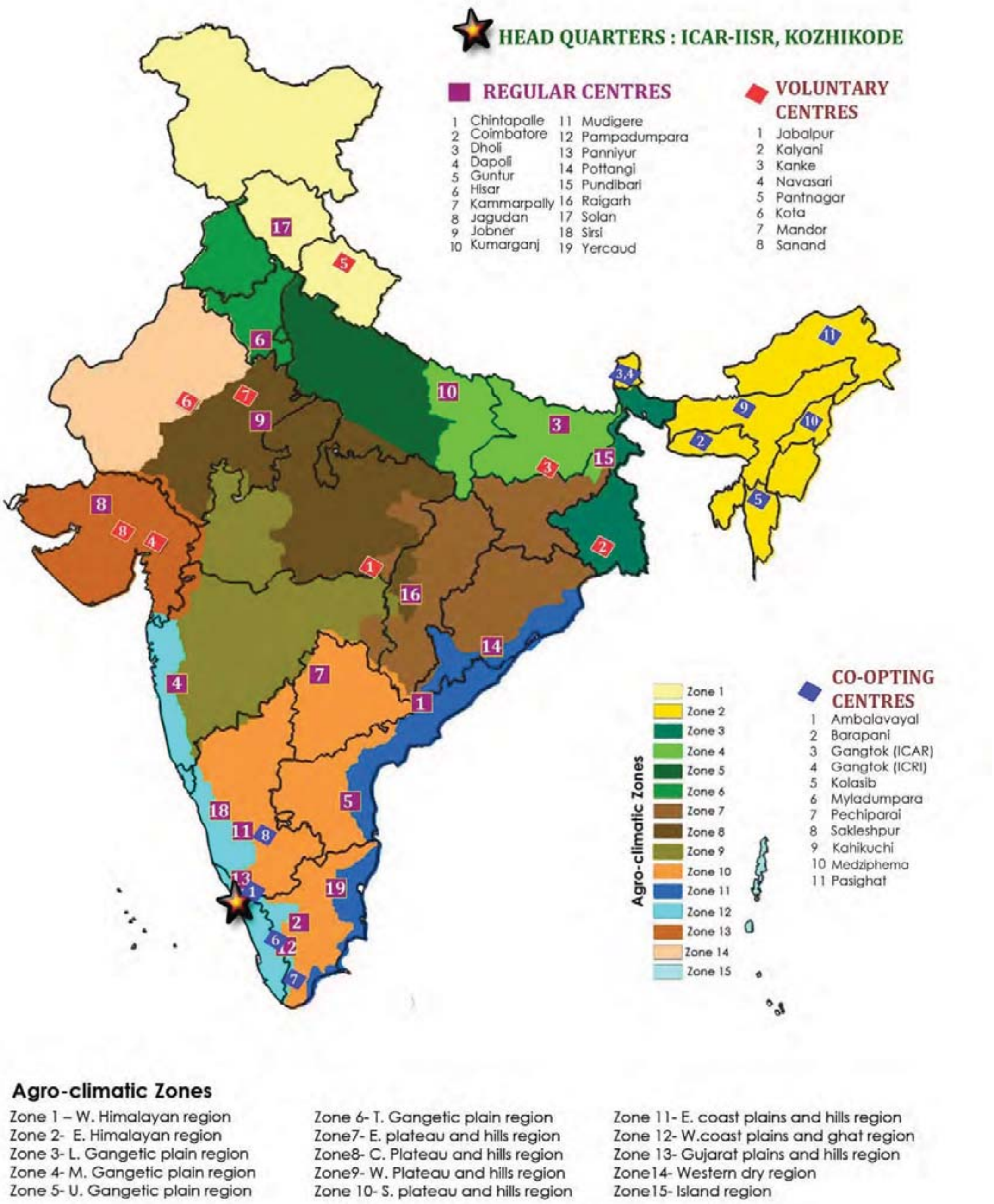
- Evolving high yielding, high quality varieties suitable for various agro-ecological situations and that are tolerant/ resistant to biotic and abiotic stresses to mitigate climate change
- Development of location specific green agro technologies for improved production with water and nutrient management, organic farming, ecologically sound control measures against pests and through mechanisation for production of quality clean spices and spice products.
- Facilitate faster adoption of proven technologies/varieties developed through technology dissemination, Field Level Demonstrations and attract youth to agriculture and agro enterprise.
- Working as an interface between State Agricultural Universities (SAUs) and Indian Council of Agricultural Research (ICAR).
- Spread the cultivation of spices to non traditional areas, North East and tribal areas for increased production. Tribal empowerment and identification of most suitable areas (crop mapping) for each of the crop.

AICRPS centres, year of start and crops handled by the centre

Sl. No.	State	University/ Institution	Centre	Year of start	Crops handled
Regular centres					
1	Andhra Pradesh	DrYSRHU	Chintapalle	1981	Black pepper, Ginger, Turmeric

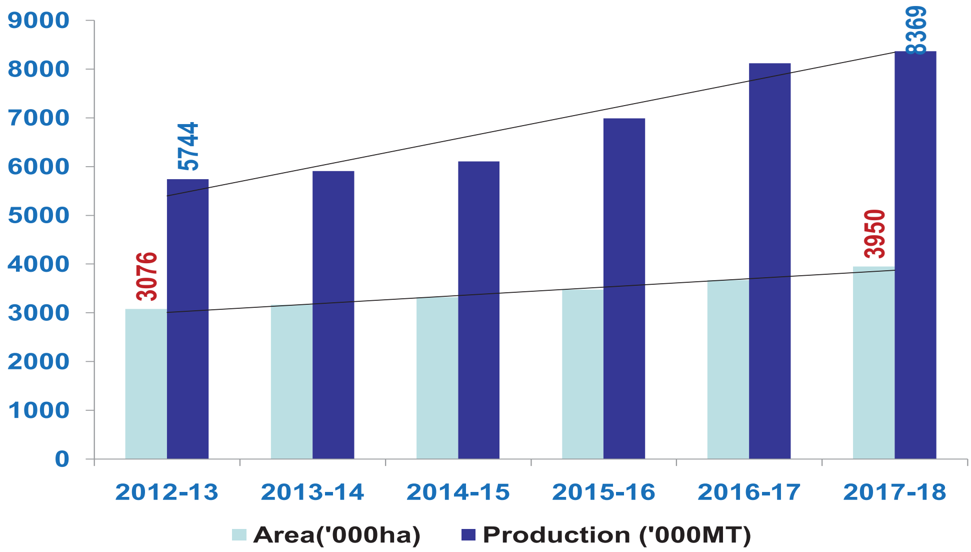
2	Andhra Pradesh	DrYSRHU	Guntur	1975	Coriander, Fennel, Fenugreek
3	Bihar	RAU	Dholi	1993	Turmeric, Coriander, Fenugreek
4	Chhattisgarh	IGKV	Raigarh	1996	Coriander, Turmeric, Ginger
5	Gujarat	SKDAU	Jagudan	1975	Cumin, Coriander, Fennel, Fenugreek
6	Haryana	CCSHAU	Hisar	1993	Coriander, Fennel, Fenugreek
7	Himachal Pradesh	YSPUHF	Solan	1971	Ginger, Turmeric
8	Karnataka	UAHS	Mudigere	1971	Cardamom, Black pepper
9	Karnataka	UHS	Sirsi	1981	Black pepper, Turmeric, Ginger
10	Kerala	KAU	Panniyur	1971	Black pepper
11	Kerala	KAU	Pampadumpara	1971	Black pepper, Cardamom
12	Maharashtra	BSKKV	Dapoli	1995	Black pepper, Nutmeg, Clove, Cinnamon
13	Orissa	OUAT	Pottangi	1975	Turmeric, Ginger
14	Rajasthan	SKNAU	Jobner	1975	Cumin, Coriander, Fennel, Fenugreek
15	Telangana	SKLTSHU	Kamarpally	1986	Turmeric
16	Tamil Nadu	TNAU	Coimbatore	1975	Coriander, Fenugreek, Turmeric
17	Tamil Nadu	TNAU	Yercaud	1981	Clove, Nutmeg, Cinnamon, Black pepper
18	Uttar Pradesh	NDUAT	Kumarganj	1995	Turmeric, Ginger, Fennel, Coriander, Fenugreek
19	West Bengal	UBKV	Pundibari	1996	Black pepper, Turmeric, Ginger
Co-opting centres					
1	Assam	AAU	Kahikuchi	2014	Black pepper, Turmeric, Nutmeg
2	Karnataka	ICRI	Sakaleshapura	2008	Cardamom
3	Kerala	KAU	Ambalavayal	2008	Black pepper, Ginger, Turmeric,
4	Kerala	ICRI	Myladumpara	2008	Cardamom
5	Meghalaya	ICAR RC NEHR	Barapani	2008	Ginger, Turmeric
6	Mizoram	ICAR RC NEHR	Mizoram	2008	Ginger, Turmeric
7	Nagaland	SASRD	Medziphema	2014	Black pepper, Ginger, Turmeric
8	Sikkim	ICRI	Gangtok	2008	Large Cardamom
9	Sikkim	ICAR RC NEHR	Gangtok	2008	Large Cardamom, Ginger, Turmeric
10	Tamil Nadu	TNAU	Pechiparai	2008	Black pepper, Cinnamon, Clove, Nutmeg
Voluntary centres					
1	Arunachal Pradesh	CAU	Pasighat	2008	Large Cardamom, Ginger, Turmeric
2	Gujarat	NAU	Navasari	2008	Black pepper, Turmeric, Coriander
3	Gujarat	AAU	Sanand	2014	Cumin
4	Jharkhand	BIRSA AU	Kanke	2008	Ginger, Turmeric
5	Madhya Pradesh	JNKVV	Jabalpur	2008	Coriander, Fennel, Fenugreek
6	Rajasthan	AUK	Kota	2008	Coriander, Cumin, Fennel, Fenugreek
7	Rajasthan	AUJ	Mandor	2014	Cumin
8	Uttarkhand	GBPUA&T	Pantnagar	2008	Turmeric, Coriander, Fennel, Fenugreek
9	West Bengal	BCKV	Kalyani	2008	Ginger, Turmeric

Agro climatic zones in India
Centres of AICRP on Spices



India has been a traditional producer, consumer and exporter of spices in the world and almost all states in the country produce one or other spices. ICAR-AICRPS works to achieve overall goal of sustainable food production and nutritional security of the country and is evident

with the increased spice production in the country. During 2017-18, India produced 8.369 Million MT of spices in an area of 3.950 million ha. The increase in spices production from 2015-16 to 2016-17 was the highest (17.4%) among horticulture crops production. In a total of 43 principal agricultural commodities exported from India, spices stand 4th place after marine products, buffalo meat and basmati rice. Indian spices are exported to more than 100 countries, however main importers are U.S.A, China, South East Asian countries, U.A.E, U.K, Germany, Saudi Arabia, Thailand,
Netherlands, Sri Lanka, Mexico, Bangladesh, Brazil, Pakistan, Japan, France, Egypt (A.R.E), Spain, South Africa and Australia. Noteworthy to mention that only around 10.00% of our spices production is exported that commends 43.00% share in volume and 48.00% in value of world Spice trade. The remaining spices are consumed in India which is an indication of the prevalence of the huge domestic market within the country.



Growth in spices- area and production

Germplasm wealth- enrichment and conservation

Collection and conservation of genetic resources of spices is the major mandate of AICRPS. India, being the hot spot of genetic diversity of spices, surveys were conducted in various spices growing belts of the country and a large number of germplasm in all the mandate crops has been assembled in the various centres of AICRPS. The AICRPS has contributed substantially since its inception by enriching germplasm, developing high yielding varieties with desirable agronomic traits; technologies for increasing the production and productivity; combating pests and pathogens to reduce crop losses. A large number of germplasm of about 8500 accessions has been conserved in 12 crops namely, black pepper (825 accessions), cardamom (309 accessions), large cardamom (313 accessions), ginger (633 accessions), turmeric (1569 accessions), clove (30 accessions), nutmeg (122 accessions), cinnamon and cassia (37 accessions), coriander (1690 accessions), cumin (653 accessions), fennel (847 accessions) and fenugreek (1398 accessions).

Improved varieties of spices for increasing farmer's income

The first hybrid variety of black pepper, Panniyur 1, developed and popularized through Panniyur center of ICAR-AICRPS is still the dominant cultivar not only in India but also worldwide.

High quality varieties- industries need

Crop	Variety	Characters
Ginger	GCP-49	Bold rhizomes with dry recovery of 21.7%
	Solan Giriganga	Plumpy and bold rhizomes suitable for western Himalayas
Turmeric	NDH-8 (Narendra Saryu)	high curcumin content (5-6%), more number of primaries suitable for powder industry
Nutmeg	IISR Keralashree	First farmer participatory bred nutmeg with extra bold fruit mace and nut
	Konkan Sanyukta	Second monoecious nutmeg variety with bold nuts, high nut oil (27%) and mace oil (17.75%)
Clove	PPI (CL) 1	First clove variety with high oil content (6%)
Cassia	IISR Cassia	First cassia variety with low coumarin content
Coriander	Ajmer Coriander -3	High volatile oil (0.55 %) with high linalool (75.42 %)
	JD (SI)-1	High oil type coriander (0.67 %)
	Chhattisgarh Sri Chandrahansini Dhania-2	Climatic resilient dual purpose coriander variety suitable for both leafy and seed purpose
Fennel	RF- 281	Bold, attractive seeds, high volatile oil (2.58%)
	RF-157	Long attractive and bold seeds.
	Ajmer fennel 3	High yielding (21.43 q ha^{-1}) and high oil (1.9%) fennel
Fenugreek	Ajmer Fenugreek 5	High antioxidant content and suitable for green leaf production under shade net condition in summer
	HM- 348	Dual purpose fenugreek
	Lam Methi 3	Medium diosgenin content (0.31%)
	Hisar Manohar	Unique green seed colour

Biotic and abiotic stress varieties- for food safe spice production

Crop	Variety	Characters
Black pepper	Panniyur 9	tolerance to *Phytophthora* foot rot
Small Cradamom	PV3 (S 1)	tolerant to drought, thrips and capsule borer
	Appangala 2	first *Katte* resistant hybrid of small cardamom
Turmeric	NDH-98	tolerance to salinity
	IISR Pragati	moderately tolerant to root-knot nematodes
	TCP 129	tolerance to leaf spot and leaf blotch
Cassia	IISR Cassia	first cassia variety with low coumarin content
Coriander	Ajmer Coriander 2	stem gall resistance
	Suruchi	off season coriander variety suitable for protected cultivation in summer

	RD 385 (Dr. RPCAU Dhania-1)	moderately resistant to stem gall disease and resistant to lodging
Cumin	Gujarat Cumin 5	high yielding wilt resistant cumin
Fennel	Ajmer Fennel-2	moderate resistance to *Ramularia* blight
Fenugreek	Narendra Methi 2	salinity tolerance and moderately resistance to *Cercospora* leaf spot and downy mildew
	RMt-354	resistant to powdery mildew and downy mildew
	Narendra Richa	dual purpose alkaline tolerant with moderate resistance to powdery mildew

Technologies for crop production and plant health management
ICAR-AICRPS has developed 176 crop wise technologies for varietal improvement, nutrient availability and plant health management in various spice crops.

- **Rapid propagation of planting materials-** The technology of rapid multiplication in ginger and turmeric through single node portray method requires only 1/4th of the actual requirement of seed and saves huge amount of planting materials and check the disease spread
- **More Crop Per Drop-** Micro irrigation and fertigation technologies standardized for black pepper, cardamom, turmeric, coriander, fennel and fenugreek.
- **Organic production technologies** standardized in black pepper, cardamom, ginger, turmeric, coriander and fennel. Good agriculture practices (GAP) and sustainable agriculture practices (SAP) were developed for spices to minimize pesticide residues and to ensure food safe spice production.
- **Integrated nutrient management-** For the maintenance of soil and plant health, inorganic nutrients combined with bioagents like *Azospirillum*, Phosphobacteria, *Trichoderma* and *Pseudomonas fluorescens* standardized for spice crops. Seed coating technology in seed spices using plant growth promoting rhizobacteria (PGPR) *viz.,* FK 14 and FL 18 isolates results in increased yield (10-30%), enhanced seed germination, improved quality and reduced storage pests of seed spices.
- **Integrated pest and disease management-** An eco-friendly way to manage *Phytophthora* foot rot of black pepper in water logged arecanut gardens by grafting black pepper on *Phytophthora* resistant root stock (*Piper colubrinum*), management of rhizome rot of ginger by biofumigation (incorporation of crop residues of mustard and cabbage in soil) and cost effective method for controlling powdery mildew of coriander (using neem seed kernel extract, NSKE) ensures sustainable spice production.

Tribal welfare- Reaching the unreached- ICAR-AICRPS technologies have also percolated to the remote and inaccessible tribal lands of Chintapalle in Andhra Pradesh, Pottangi in Odisha, Raigarh in Chhattisgarh and NE states providing employment opportunities (especially to women) and uplifting the economic status of farmers by supplying quality planting materials and giving training programmes on high production technologies. Also, expanded the production of spices especially turmeric, ginger and black pepper in their nontraditional areas of cultivation.

North East- Exploring the unexplored- ICAR-AICRPS works for the development of North Eastern regions through its seven centers located in six NE states catering the research on crops like black pepper, ginger, turmeric and large cardamom. Organic production packages of large cardamom for North East and Large cardamom Guide has been published in collaboration with Spices Board.

ICT Application in Agriculture Sector

Sunil V G
Assistant Professor, KVK Malappuram, Kerala Agricultural University

The benefits of the green revolution greatly improved agricultural productivity. However, there is a demonstrable need for a new revolution that addresses the new challenges of agriculture. The farmers need information on what to produce, when to produce, where to produce and how to produce. On the other side the consumers need produce at lower price and at good quality. Public and private sector actors have long been on the search for effective solutions to this question. Information and communication technologies (ICT) are one of these solutions, and have recently unleashed incredible potential to improve agriculture.

With the booming mobile, wireless, and Internet industries, ICT has found a space even in poor small holder farms and in their activities. The ability of ICTs to bring refreshed momentum to agriculture appears even more compelling in light of rising investments in agricultural research, the private sector's strong interest in the development and spread of ICTs, and the upsurge of organizations committed to the agricultural development agenda.

ICT Applications from Kerala

Kerala started innovating various ICT application right from 2004. Some of the promising application with developmental and other details is described below.

A. Mobile application

1. FEM@Mobile: Fem@mobile is a mobile application on agriculture containing information on 100 crop plants of Kerala. It is first of its kind with over 1000 pages of content information. The information is well structure and edited for the use of mobile users. The total size comes below 600 kb thus making it easy for download. It is available for free download at Google play store.

B. Information systems

1. Harithakeralam: This forms the first basic work in agricultural software. It was developed by Kerala state IT Mission in 2004. The original work was in flash platform and published in CD format. It covers over 50 major crops of Kerala and contains a number of animated videos. The CD version is now available in www.celkau.in.

2. Kissan Kerala Information System: The online information system covers basic details on over 100 major crops of Kerala. The online 'fertilizer advisor' and 'contact an expert' forms the uniqueness of the system. A good collection of FAQs are also maintained. The project is run by Department of Agriculture and IIITM-K. The contents are available in www.kissankerala.net

3. Karshikajalakam: This information system covers details of major crops, animals and fisheries aspects. A pest doctor and crop calendar makes the information system still relevant. A number

of small video clipping were used to depict real field situation. Developed by KAU originally as a CD version, the contents are now available in www.celkau.in.
4. Crop Health Decision Support System: This software covers plant protection aspects of major crops of Kerala. Good quality original photos with comprehensive management recommendation are the salient feature. The problem identification is done through photo-graphs. This software is developed by a team of KAU scientists. The content is available at www.kissankerala.net.

5. Farm Extension Manager: The farm extension manager covers the major five crops of Kerala in detail. It has an online fertilizer calculator, pest doctor, management guide, irrigation advisor, crop planner etc. Besides, the agri-business and veterinary aspects are also covered in detail. Developed by KAU, the contents are available online at www.farmextension manager.com

6. Flowering plants of Kerala: This is a classical work done by Kerala Forest Research Institute, Peechi. It contains botanical information on over 5000 plants of Kerala with good quality photos. The scientific names, local name and English names are also included. The CD is highly useful for identification of plants in Kerala. CD version is available at KFRI, Peechi for sale.

7. Medicinal and aromatic plants: This is a work in flash platform on over 300 medicinal plants of Kerala. A detailed information sheet with quality photos on each plant is included. The Aromatic and Medicinal Plants Research Station, Odakkali has developed the software. The CD can be purchased from the centre.

8. KAU Agri-infotech Portal: The portal provides detailed information on important crops of Kerala besides fisheries and veterinary aspects. The KAU Fertulator, KAU E-Crop Doctor and media gallery make the portal unique. The e-learning platform was the first of its kind in Kerala. Developed by Center for E-Learning, KAU, Vellanikkara, the link to the website is www. celkau.in.
9. ATMA Kerala: The department of agriculture has recently developed an information system for displaying innovations and success stories of ATMA from various districts. The monthly technical advisory from various districts, the field trials conducted, the farmers' field school etc is uploaded in this website. The link is www.atmakerala.in

C. Expert systems
1. Fertilizer Calculator: The newly developed tool under farm extension manager has over 200 recommendations of almost all plants covered in the package of practice of KAU. The online tool facilitates you to modify the blanket recommendation according to soil test values. The final recommendations can be taken in the form of straight or complex fertilizers. Available in www.farmextensionmanager.com
2. KAU Fertulator: The tool helps to have the fertilizer recommendation for all the crops covered in the package of practice. The specialty of the tool is that the recommendation will be available

for all the commonly used fertilizers. The users have to download the software available in the www.celkau.in before use.

3. KAU E-Crop Doctor: The tool helps you to have a realistic estimation of the quantity of pesticides recommended for the crop plants of Kerala. The details of trade name and quantity for various units can be easily taken from the information system. The users have to download the software available in the www.celkau.in before use.

4. Credit Calculator: The tool helps to have a realistic estimate of the eligible finance under crop loan component from nationalized banks. Developed based on the concept of scale of finance, the software also takes care of the loan for intercrops as well. The final repayment amount with the interest portion is worked automatically based on the area of cultivation. Available at www.farmextensionmanager.com

D. Information Kiosk Based models

1. Agricultural Kiosk: The kiosk version developed by scientists of KAU, covers around 10 crops. The contents cover all aspects of crop production. The soft-ware is being imple-mented in the Kiosks promoted by the Department of Agriculture, Govern-ment of Kerala. To get a copy of the software you need to contact the Extension Department of Agricultural College, Vellayani.

2. Nelkrishi.com: The tool is developed by a team of KAU scientists exclusively for touch screen kiosk. The information system contains over 500 pages of information on rice cultivation. The use of over 500 good quality photos and six videos makes the learning process simple. The contents are available in www.farmextension manager.com

3. Vegetable cultivation: Developed by Green Touch Media, Trivandrum for the Department of Agriculture, Government of Kerala, and the DVD contains information with video clippings on around 15 vegetables. The organic production aspects are also well taken care off. The software available in www.celkau.in.

E. Social media groups

1. Kissan Kerala Agricultural Video Channel: It is a YouTube link where over 500 videos in agriculture, veterinary and fisheries are uploaded. The material offers excellent opportunity to learn from a real field situation. More than 75 lakh people have viewed these videos. The project is run by Department of Agriculture and IIITM-K. Address: www.youtube.com/user/kissankerala

2. Adukkala Thottam' group: It is one of the biggest agricultural face book groups in Kerala. It has over 85000 members. One of the specialties seen in the group is that members even send seeds to others through post for promotion of kitchen garden. Initially ten seeds are given and when the new member grow the seed and put the photo of the crop in face book more seeds are given. The group members also meet frequently at a common place and share their experience in farming.

Conclusion

These examples represent only a minute subset of the information and communication services that can be provided to the agricultural sector through increasingly affordable and accessible ICTs. Hundreds of agriculture-specific applications are now emerging and are showing great promise for smallholders. It is too early to have a clear idea, of how ICTs support agricultural development, and under what conditions. While there is credible evidence of positive impact, questions remain about how to make these innovations replicable, scalable, and sustainable for a larger and more diverse population.

References:

1. Jac Stienen, Wietse Bruinsma and Frans Neuman (2007), How ICT can make a difference in agricultural livelihoods, The Commonwealth Ministers Reference Book, in: www.iicd.org/files/ICT%20and%20agricultural%20livelihoods.pdf

2. World Bank Group (2012), ICT in Agriculture Sourcebook, in:http://www.ictinagriculture.org/sourcebook/ict-agriculture-sourcebook

3. Wikipedia (2013), ICT in agriculture, in: en.wikipedia.org/wiki/ICT_in_agriculture

Vanilla: Cultivation and Processing

R. Ramakrishnan Nair
ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

Vanilla- the most important and popular flavoring material and spice of commerce is obtained from the fully grown but un-ripened fruits (capsules, commonly referred to as beans) of the climbing orchid *Vanilla planifolia* Andrews (syn. *V. fragrans* Salisb.). Beans after fermentation-curing process produce the characteristic aroma. *Vanilla* is the only genus of *Orchidaceae* which is useful as a spice and has a real economic value in the food industry and perfumery, owing to its unique flavor and pleasant aroma.

Other species of *Vanilla* namely, *V. pompona* Shiede. (West Indian vanilla) and *V. tahitensis* J. M. Moore (Tahiti vanilla) also produce vanilla beans commercially. But, vanilla produced by these species is considered to be inferior in quality compared to the high quality vanilla produced by *V. planifolia* (Mexican vanilla). The most extensively cultivated species is *V. planifolia*, a native of South-eastern Mexico, British Honduras, Guatemala and Costa Rica (Ridley 1912).

This plant has been introduced into all parts of the tropics, and has been cultivated extensively in Malagasy Republic (Madagascar), Reunion and the Comoro Islands (Purseglove *et al.* 1981). At present, the major vanilla growing countries are Madagascar, Indonesia, China, Papua New Guinea and Mexico (FAOSTAT database 2018). Vanilla production in different countries during 2016 is presented in Table 1.

Table 1. Vanilla production in different countries during 2016

Sl. No.	Country	Area (ha)	Yield (kg/ha)	Production(tonnes)
1	China	6933	127.6	885
2	Comoros	63	245.8	15
3	French Polynesia	231	102.7	24
4	Guadeloupe	41	272.6	11
5	Indonesia	14104	163.4	2304
6	Kenya	22	683.8	15
7	Madagascar	67823	43.1	2926
8	Malawi	79	260.4	20
9	Mexico	979	524.0	513
10	Papua –New Guinea	1863	269.6	502
11	Re-union	322	64.2	21

12	Tonga	267	673.0	180
13	Turkey	-	-	303
14	Uganda	405	521.4	211
15	Zimbabwe	26	416.3	11

Attractive fragrance and flavor of vanilla beans is due to numerous aromatic compounds produced during the curing operation among which vanillin ($C_8H_8O_3$) is the most important. The flavor of vanillas produced at different parts of the world varies due to climate, soil, extent of pollination, degree of ripeness at harvesting and method of curing (Purseglove *et al*. 1981).
Vanilla essence is largely used in the preparation of ice-creams, chocolates, bakery products, puddings, pharmaceuticals, liquors and perfumes. Medicinal properties of vanilla have been reviewed by Ravindran (2006).

In India, vanilla cultivation has been gaining attention in the states of Kerala, Karnataka and Tamil Nadu since early 1990 and gained a momentum only during 2001-2004. Estimated area under vanilla cultivation in India was around 1600 ha during that period (Potty, 2003). Price of green vanilla beans which was Rs. 100/- per kg in the year 1995 spurted to Rs. 800/- per kg in the year 2001-2002. Price of cured beans which was Rs. 2000/- per kg in 1995-96 was increased to around Rs.8000/- per kg by 2003 (Nambiar 2003). But, during the harvesting season of 2004 the price started declining due to the sudden withdrawal of private companies from Indian vanilla market and by 2005 the price of fresh vanilla bean was around Rs.200/- per kg. Presently, India's presence is not reflected among the vanilla producing countries of the world (FAOSTAT database 2018).
During 2016, when a vicious cyclone hit Madagascar, experts feared one-third of the country's vanilla crop was destroyed. With the island nation off the coast of southeast Africa producing 80-85 percent of the world's vanilla, speculation shot up prices and tightened supplies. Even with improving supply, vanilla prices remain stubbornly high. In the summer of 2017, market prices reportedly hit $600/kg, then fell slightly. The 2002 market crash left premium pods selling for $20 a kilo. Vanilla at $100 a kilo used to be a fair to average price.
Currently the Indian scenario regarding vanilla appears to be promising. The price of vanilla has more than doubled in the past 20 months, but Indian farmers have not been able to reap much benefits from this

The price of dry vanilla beans of premium variety, which was ₹ 14,500 per kg in March 2016, has risen to more than ₹ 35,000 per kg now.

The upward movement of price of the produce in India commenced from March 2015 itself. The price of dry beans, which was ₹ 11,500 per kg in March 2015, increased to ₹ 14,500 by March

2016. Following this, the prices surged further and it was being purchased at ₹ 25,000 by March 2017. In the past nine months, prices have risen by 40%.
In India vanilla is grown largely in Karnataka, Kerala and TamilNadu. In the early years of cultivation, the fungal diseases are of less concern as their incidence was very meager and limited to only certain areas. But with the advent of intensive and wide spread cultivation, the occurrence of the diseases also became common and wide spread. Among the diseases occur in India the stem rot and root rot caused by *Fusarium oxysporum* f.sp. *vanillae* is the most damaging (Balagopal et al.,1979).

Botany
Vanilla planifolia Andrews (syn *V. fragrans* (Salisb.) Ames) is indigenous to the humid tropical rain forests of South-eastern Mexico, Central America, West - Indies and Northern part of South America, where it is growing wild as a climber. In a wild state *V. planifolia* usually grows climbing on trees in wet lowland forests. Vanilla thrives well from sea level up to 1500 meters MSL under hot, moist tropical climate with adequate well distributed rainfall. Natural growth is obtained at latitudes, 15 degree North and 20 degree South of equator. The optimum temperature ranges from 21-32°Cand rain fall 2000-2500 mm annually. Partial shade is necessary and this is usually provided by the shrubs or small trees up on which wines are trailed. The crop requires a short dry spell of about two months for flowering.

Taxonomically, the genus *Vanilla* comes under family *Orchidaceae*, subfamily *Epidendroideae*, tribe *Vanilleae*, and subtribe *Vanillinae*. About 200 species of *Vanilla* have been recorded. The commercially important species of *Vanilla* are *V. planifolia* Andrews (Syn. *V. fragrans* (Salisb.) Ames, *Epidendrum vanilla* L., *Myrobroma fragrans* Salisb., *V. mexicana* P. Miller, *V. aromatica* Swartz, *V. planifolia* B D. Jackson) - the true Mexican vanilla, *V. pompona* Schiede (Syn. *V. grandiflora* Lindl., *V. lutescens* Moquille – Tand, *V. surinamensis* Reichb f., *V. planifolia* var. gigantea Hoehne) – West Indian vanilla, Guadeloupe vanilla, Antilles vanilla and *V. tahitensis* J. W. Moore – Tahitian vanilla. *Vanilla planifolia* is the only species commercially cultivated in India.

Vanilla planifolia is a fleshy, herbaceous perennial vine, climbing by means of adventitious roots. It grows to a height of about 10-15 m supporting itself on the host trees or other supports. Under cultivation conditions, vanilla is trained and pruned to a height that will allow hand pollination of the flowers and subsequent harvest of the beans. If allowed to grow continuously on un-branched trees like coconut or areca-nut palm the vine will grow even up to the top of the tree, without producing any branch. The stem is long, cylindrical in shape and monopodial in growth pattern with or without branches. The branches produced from the central stem will always remain subsidiary to the main stem. Stem is succulent, flexuous and brittle. It is usually 1-2 cm in diameter and is dark green and photosynthetic with stomata. The internodes are 5-15 cm in length. Stem thickness and internode length in newly raised cuttings are less compared to the mature vines, but attain normal size as they grow to maturity. Leaves in fully grown vines are large, plane, fleshy, sub-sessile and dorsi-ventral. They are oblong- elliptic to lanceolate in shape, 8-25 cm long and 2-8cm broad and alternate in arrangement. Tip is acute to acuminate and the base is almost rounded. The veins are numerous, parallel and indistinct. Short and thick petiole is canalized at adaxial side. Leaves in newly raised cuttings and seedling progenies are small in size but attain the normal size within 3-4 years of growth. Two types of roots are observed in vanilla. They are aerial roots which help the plant in climbing supports and terrestrial roots which help the plant in absorbing nutrients from the soil. Occasionally long aerial roots resembling buttress roots are produced from the main shoot or branches, which grow down to soil and function as feeding roots. This usually happens when feeding roots are damaged or the stem of the plants are cut interstitially by disease infection or by mechanical damage. The aerial climbing roots are long, greenish white, adventitious, about 2mm in diameter and are produced singly from the nodes, slightly away from the point of leaf attachment. They adhere firmly appressed to the support, upon which the plant grows. The outer parchment-like sheath or velamen is rather poorly developed. The terrestrial roots ramify in the humus or mulch layer and have root hairs. Endotrophic mycorrhiza is reported to be present in terrestrial roots. The adventitious roots produced at the nodes in *V. planifolia* either adheres to the supports or dropped freely to the ground where they branch. Some, he noted, remained above the soil while others achieved a shallow penetration. The aerial roots are free of hairs while those that penetrated the leaf litter produce hairs.

Inflorescences are stout axillary racemes, usually simple and rarely branched. It has been observed that certain plants frequently produce branched inflorescences. Inflorescences are usually borne towards the top of the vine in the leaf axils of stems with sufficient maturity and are 5-8 cm long. There may be as many as 100 flowers in a raceme but usually there are about 20. Branched inflorescences usually have 40-50 flowers. Flowers open from base to upwards, generally with only 1-3 flowers open at a time. Unlike the other ornamental orchid flowers, vanilla flower will remain for only one day and shed off by next day, if not pollinated. The rachis is stout, often curved and 4-10 mm in diameter. Bracts are ovate, rigid, concave, persistent, 5-15 mm long and about 7mm wide at the base. In India, flowering is observed usually from December to May and it takes 45-60 days from the initiation of inflorescence to flowering

Flowers are large, waxy, pale greenish-yellow in color, zygomorphic in symmetry and are bisexual. Fully opened flowers are about 10 cm in diameter and are fugacious. The pedicel is very short. Sepals and petals are three each in number. Sepals are oblong-lanceolate, obtuse to sub-acute, slightly reflexed at the apex and are 4-7 cm long and 1-1.5 cm wide. The two upper petals resemble the sepals in shape, but are slightly smaller. The lower petal is short, broad and modified to form the trumpet-shaped lip or labellum. Labellum is 4-5 cm long and 1.5-3 cm broad at its widest point. It is attached to and envelops a central column comprised of the united stamen and pistil (gynostemium). The tip of the labellum is obscurely three lobed and is irregularly toothed on its revolute margin. There are longitudinal verrucous darker colored papillae forming a crest in the median line and with a tuft of hairs in the middle of the disc. The cultivars available at India have a tuft of imbricate scales in the middle of the disc, instead of hairs. A diagrammatic view of vanilla flower is presented in Fig.1.

The column or gynostemium is 3-5 cm long and is attached to the labellum for most of its length. The single anther is at the apex of the column and hangs over the stigma, but a flap or rostellum separates them, preventing natural pollination (Fig 2. A & B). The anther contains two pollen masses or 'pollinia' covered by a cap. But some researchers are of the opinion that, in *V. planifolia* the pollengrains do not remain united to form compound grains, massulae, or pollinia, but lie freely inside the anther. If this is true, the clump-like appearance of pollen may be simply due to stickiness.

The slender stalk-like portion of the flower is the ovary which is inferior, cylindrical, often curved, 4-7 cm long and 3-5 mm in diameter. Ovary is tri-carpellary, syncarpus and unilocular. A cross section of the ovary of an opened flower shows three carpels, three pairs of fibrovascular bundles, and three pairs of placentae. The placentae extend throughout the length of the ovarian cavity. The three parietal placentae in the ovary of non-pollinated vanilla flower is weakly developed and separated from each other by the smooth inner epidermis of the ovary. Pollination triggers the placenta to begin extensive branching followed by ovule development.

Climate and Soil

Well distributed annual rainfall from 150- 300 cm humid tropical climate is ideal. Very high relative humidity is not desirable as it favor diseases. Partially cleared forest areas are ideal. Very dry climate and direct incidence of sunlight on vanilla vines is not desirable as it weakens the plant. Absence of rain during flowering season (December to March) and harvesting season (September to November) is desirable. Loose loamy top soil with high humus content is ideal for the healthy growth of vanilla. However, vanilla grows in diverse soils ranging from sandy loam to red laterite. Slightly sloppy areas are better than perfectly plane areas as better drainage is possible in the former.

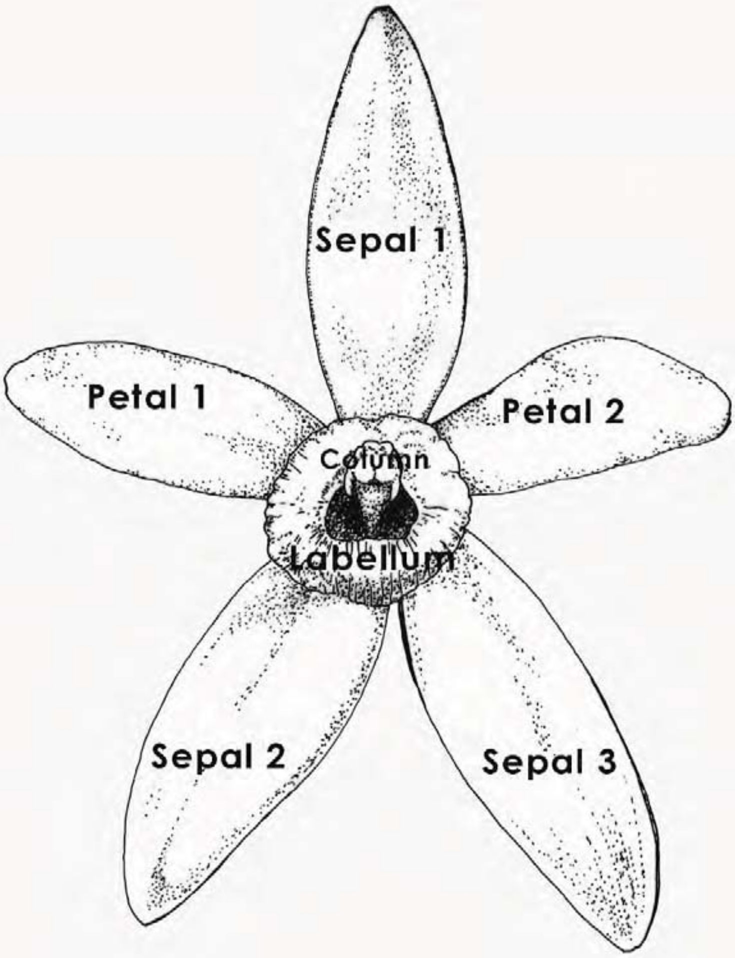


Fig 1. A Diagrammatic front view of vanilla flower

Support Trees or Standards

Vanilla is a climber which requires a support tree to climb on and grow. Thus, a suitable support tree has to be planted before planting vanilla for successful cultivation. The support trees should also protect the vines from severity of sunlight by providing moderate shade. A good support tree should have rough non-peeling bark, small leaves and should be growing fast and branching early. A few of the commonly used support trees are *Gliricidia maculate, Erythrina lithosperma, Jatropha carcus, Casuarina equisetifolia, Pleumeria alba, Morus* sp. (Mulberry). *Gliricidia* is considered as an ideal support tree as it enhances soil fertility. The branching of support trees should be regulated at a height of 1.5 to 2.0 m.

Spacing and planting of support trees

In cultivation as a monocrop the spacing should be1.5 m between plants and 2 m between rows. In coconut and arecanut plantations spacing can be adjusted based on the interspace available between the trees. While planting the stem cuttings of support trees like Gliricidia, the cutting should be of at least 5.0 cm thickness and 1.5 to 2.0 m length. These can be planted in 30 cm^3 pits refilled with top soil in its centre. The support trees should be planted at least 6 months before planting vanilla.

Vegetative Propagation of Vanilla

Vanilla is cultivated commercially through vegetative cuttings. Planting of cuttings having 15-20 nodes (1.5-2.0 m) in the field will result in early flowering (Within 2-3 years). The use of cutting having less than 50 cm length should not be used for direct planting in the field as it will affect the establishment. Small cuttings can be used to raise rooted cuttings in poly bags and subsequently planted in the field. Tissue culture-derived plants have to be grown in the nursery at least for one year and can be planted in the field while they attain more than 50 cm height.

Method of planting

Cuttings from healthy plants with active growth have to be collected and make into pieces having at least 1.0 m length. Avoid using cuttings from senile plantations and already fruited branches for planting. Remove 3-4 leaves from the basal region of the cuttings and store them in the shade for one week before planting. One cutting per standard is enough for planting. Treating of cuttings with fungicide (Carbendazim + Mancozeb) solution will ensure disease free establishment.

Plant the cuttings near the support tree in such a way that the basal region from which leaves removed will be under the soil and the cut end just project above the soil. This will avoid infection through the cut end. The upper growing part of the cutting should be tied to the standard. Mulch the planted area around the support tree with straw, dried leaves, coconut-husk etc. Giving a shade to the cutting till thy sprout will be desirable. Give light irrigation till the sprouts emerge. Within 1-2 months, new roots will emerge from the basal region and sprouts will emerge from upper growing region.

Tissue culture-derived plants and rooted cuttings raised in the nursery with sufficient length can be directly planted near standards and they will continue the growth and produce new leaves with two weeks.

Method of planting is demonstrated in Fig.2.

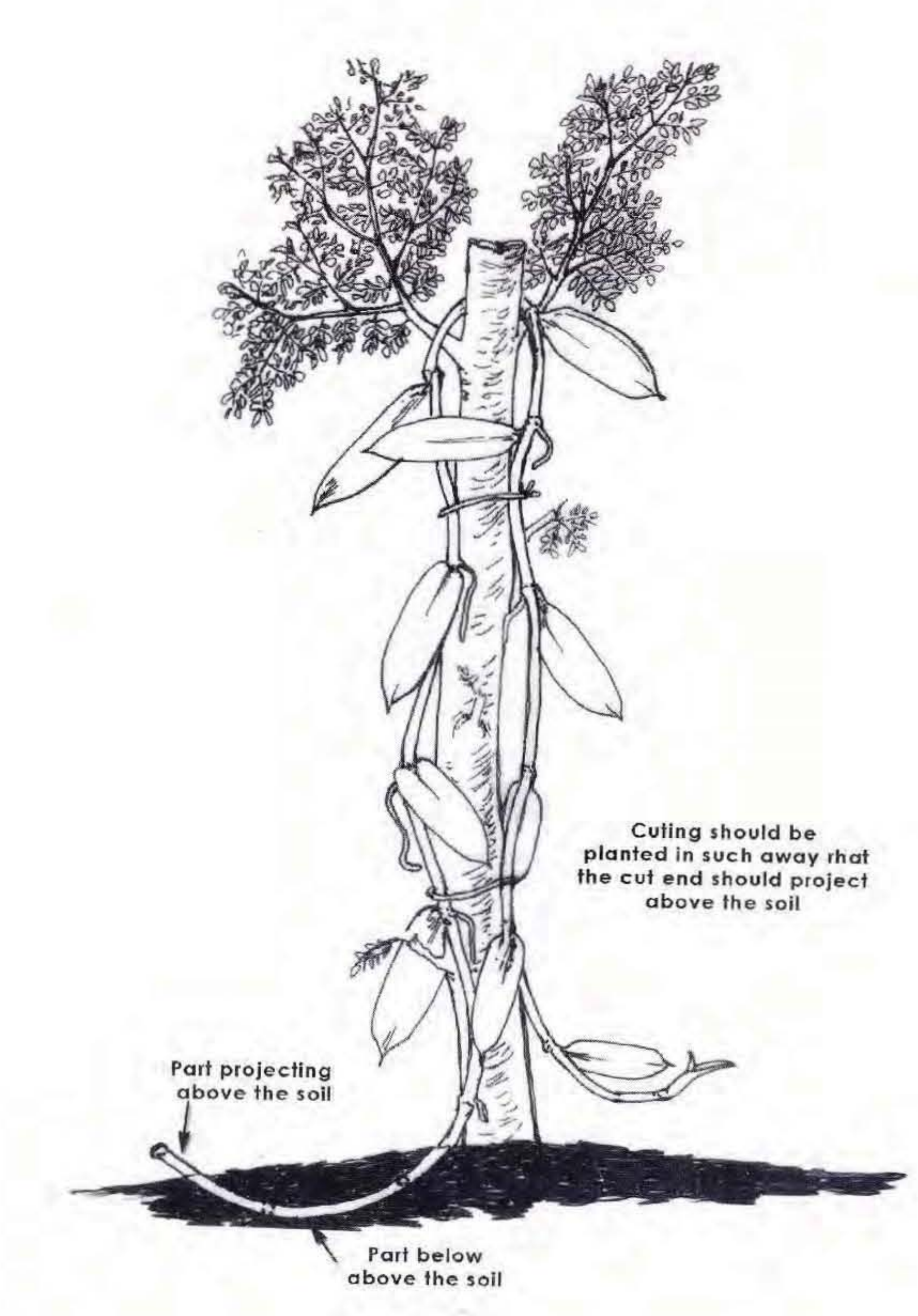


Fig.2. Method of planting vanilla.

After Care

Once vines established, regularly visit the plantation to regulate the growth of support trees as well as disease /pest control of plants. Vanilla plants prefers a thick mulch of organic matter and humus which is the main nutritional source of plants. Therefore, regular mulching with dried leaves, application of dried cattle manure and compost will help the healthy growth of vines.

During initial one or two years of growth, irrigate the plants regularly. Two to three liters of water per vine per week is sufficient. Remove the weeds growing around the vines allow to dry and use them as mulch. No cultural operations should damage the roots of vanilla plants which are mostly found near the soil surface. New sprouts should be allowed to by climbing to the support tree. To increase the number of branches, shoot tip after sufficient growth can be nipped off, so that new axillary branches will be produced.
As the support trees grow they should be pruned at a height of 1.5 to 2.0 m. This will produce an umbrella like canopy which will provide shade to the vanilla plants and also produce sufficient branches for vanilla vines to climb. If the support trees are not of leaf shedding nature the canopy has to be regulated by pruning the branches so as to provide sunlight to the plant, during rainy season. By the onset of harvest also the branches of support trees have to be pruned so that it will enhance the maturity of fruits and also facilitate production of new inflorescences for the next season.

Growth and training of vines
Vines should be allowed to grow up through the main stem of support tree from the very beginning. They should never be allowed to creep on the ground. However, the upward growth should not be allowed indefinitely which will adversely affect flowering and also make artificial pollination inconvenient, if at all flowers. Therefore, once the vine reaches 120-150 cm height through the support tree, the vine should be allowed to grow downwards by hanging on the branches of the support tree. While the vine touches the ground, a part of it should be covered with mulch and soil and the tip should be again allowed to grow upward through the main stem of support tree. Like this 5-6 branches can be grown in a plant. The vines have to be trained in this way so as to facilitate pollination.

Pruning of vanilla vines
Arresting the vegetative growth of vanilla vine by pruning will activate reproductive phase. A method of pruning for induction of flowering was described by Lionnet (1958). Based on this method, at the time of pruning special bearing branches are prepared. These are shoots which when 1 -1.2 m long are bent down around a branch of a support tree slightly twisted in the process with tip pruned at about 45 cm above the ground. Any shoots appearing on the bearing branches themselves are removed when 7.5 – 10 cm long but the shoots appearing on the rest of the plant before the bends are allowed to grow. They will constitute the bearing branches for the following year. Training and pruning of vanilla is demonstrated in Fig.3.

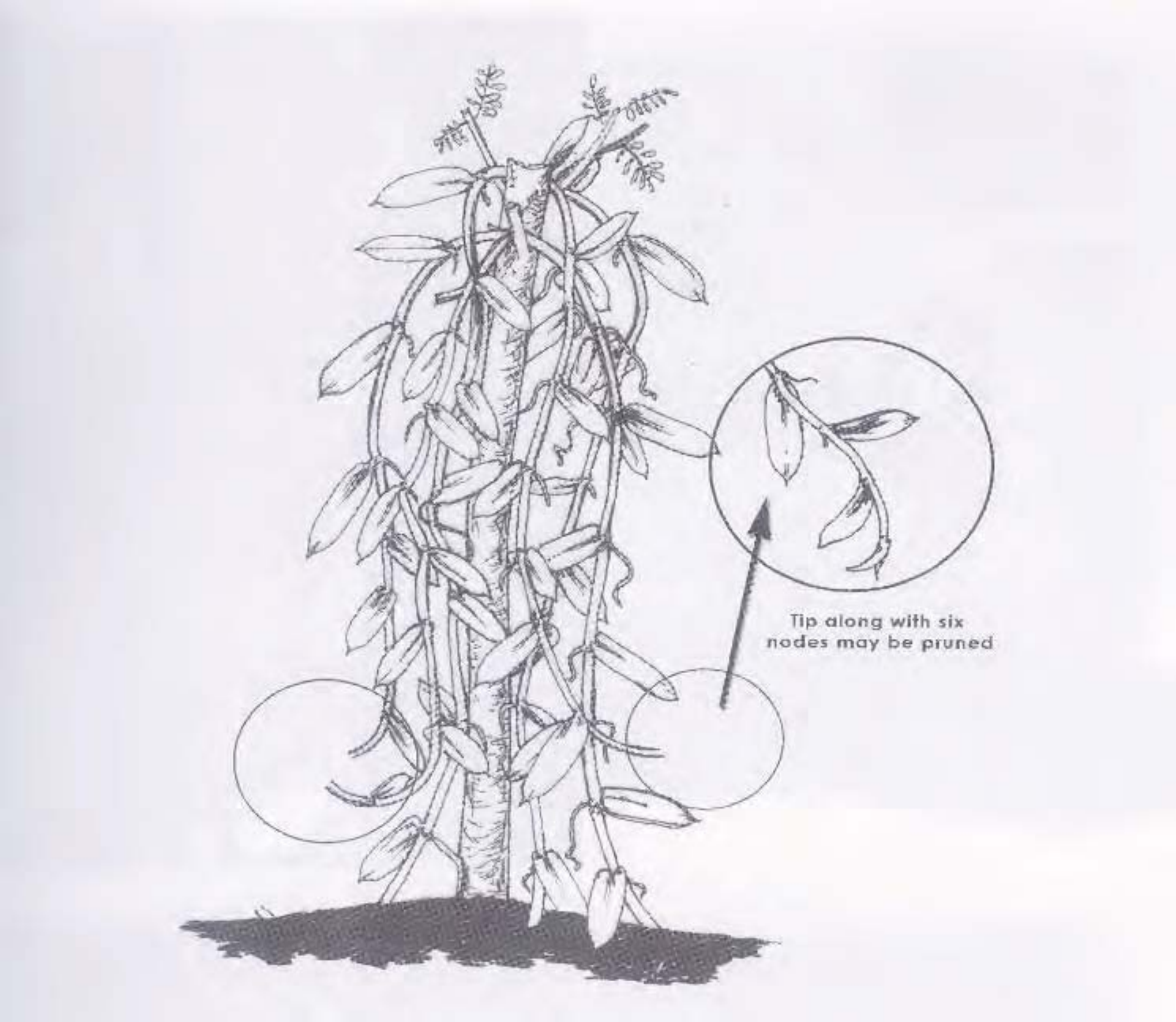


Fig. 3. Training and pruning of vanilla

As a result of bending and pruning there is a reduced sap flow towards the bearing branches which favors flower formation. After harvesting the beans, the old branches are cut off. Meanwhile the following years bearing branches have already been prepared. Thus a vine after three to four years' growth will be having a number of shoots hanging down over the branches of the support tree. There are usually five to six bearing branches per plant but strong vines will have more. In south India also some vanilla growers are practicing the same method. Some farmers are of the opinion that folding the leaf at the bend portion of hanging shoot will activate the axillary bud to produce new shoot, provided the tip of hanging shoot has already been removed.

In Puerto Rico, growers used to remove only 15 cm of the growing shoot tip each year some time before flowering. The removal of this piece apparently results in an accumulation of carbohydrates and other substances which encourage production of inflorescences in the axils of the leaves on the hanging branches (Childers *et al.* 1959).

Ridley (1912) suggested that the old stems should be cut off after flowering, even if they still carry buds. The plant will replace them with good and strong stems bearing more flowers, and probably better fruit than the old stems would by the next flowering season.

Fertilizers and manures

Chemical analysis reveals considerable amount of inorganic nutrients taken up by the different organs of vanilla (Tjahjadi 1987). Nutrients such as calcium magnesium and potassium were found in higher amount in the stem, leaf and fruit respectively. Except for calcium and magnesium all other nutrients were found to be at higher level in fruits. This result indicates that the inorganic nutrition should be considered with sufficient importance in vanilla.

It is recommended that 40-60 g N, 20-30 g P2O5, and 60-100 g K2O be supplied to each vanilla vine per year (Anandaraj *et al.* 2001). Spraying of 1% solution of 17:17:17 NPK mixture on the plant once a month for enhancing growth and flowering.

Nutritional studies carried out at the Indian Cardamom Research Institute has indicated that vanilla yield can be enhanced by soil application of 20: 10: 30 g NPK per vine per year and foliar application of urea, single super phosphate and muriate of potash at the rate of 1.0, 0.5, and 1.5 per cent respectively during January, May and September (Potty and Krishna Kumar 2003).

Organic fertilizers such as guano and bone meal are found to be beneficial to vanilla (Purseglove *et al.* 1981). The use of fresh farmyard manure reported to increase the risk of infection due to diseases (Lionnet 1958). Composting before soil application of the animal manure together with other crop wastes such as rice straw, circumvents this problem. Loppings, especially the leaves of leguminous support trees are a very good source of green manure (de Guzman 2004).

Plant protection

Normally, under the clean cultivation practices vanilla will be free from diseases and pest infection.

However, under conditions like severe drought, direct incidence of sun light, Malnutrition, Intensive pollination and fruit set will affect the health of plants and make them vulnerable to disease infection.

Very high humidity, continuous rain, insufficient drainage and water logging, intense shade and mechanical damage to roots will also make plants vulnerable to disease infection. Use of infected planting material in case of viral diseases.

Fungal and viral diseases are of common occurrence in vanilla, but so far no bacterial disease has been reported from any of the producing countries.

Fungal diseases

Vanilla is highly susceptible to a number of plant parasitic fungi that causes serious diseases, some of which result in total collapse of the vines. All the plant parts like roots, stem, leaves, beans and inflorescence are vulnerable to attack by the parasitic fungi. Fungal infections often lead to rotting of affected parts or wilting of the entire vine. Species of fungi viz. *Phytophthora, Fusarium, Sclerotium, Calospora, Colletotrichum and Cylindrocladium* are the main pathogens that cause serious damages to the crop. Close planting, excess shade, intensive crop management with manures, frequent irrigation and lack of phytosanitory measures are the factors that predispose the plant to infection by these fungi.

Stem rot

Symptoms

Water soaked lesions appear at the leaf axils and extending to both sides of the stem Later, elongated patches develop on the stem which results in rotting and drying of the tissues. In advanced stages, the leaves and rest of the stem turn yellowish and later dry off. When the stem in the basal or middle portions of the vines are infected and shriveled, the remaining distal portions show wilting symptoms. If sufficient number of aerial roots are not fixed in the soil, the vine will collapse in no time. The disease has been reported from many parts of Indonesia especially Java, Bali, North Sulawesi and North Sumatra. In India, stem rot disease is found as a serious threat to many vanilla plantations

Causal organism

Stem rot is caused by *Fusarium oxysporum* f.sp. *vanillae* (Tombe *et. al*. 1992).

Control

Disease can be controlled by spraying 0.2 percent Mancozeb together with Carbendazim (Tomb & Sitepu, 1986).

Stem blight

Symptoms

The disease is characterized by the development of water soaked brown coloured blighted patches extending along the stem. The affected portion gradually shrinks, the leaves become yellowish and the vines dry off. Stem blight was reported for the first time from French Polynesia (Tsao & Mu, 1987). The disease is also noticed in India very often during summer months.

Causal organism

The disease is caused by *Phytophthora* sp. A number of *Phytophthora* species were reported to be associated with the disease viz. *P.palmivora, P.capsici,* and *P.parasitica.* Suseela Bhai &Joseph Thomas (2000) reported *P. meadii* in association with the disease.

Management

The spread of the disease can be controlled by spraying with 1 percent Bordeaux mixture or Potassium Phosphonate (0.4%).

Root rot

Symptoms

The disease usually occurs during the post monsoon periods when the temperature rises very high. The infection appears in the form of browning of the root tips touching the soil. In advanced stages of infection, the roots decay and result in the death of the underground roots.

The affected plants produce numerous aerial roots, but most of them die before they touch the soil. The stem and leaves also become flaccid, stem shrivels and the vines show a wilted appearance. The disease is aggravated during dry periods due to excess sunlight and the vines become less capable of withstanding the infection due to lack of adequate translocation of water and minerals. Root rot is found to be a serious problem in many vanilla plantations in India. It has been reported for the first time by Childers and Cibes, (1948) from Puerto Rico and noticed in isolated gardens where the drainage is very poor.

Causal organism

Root rot is caused by *F. oxysporum* Schlecht..f.sp. *vanillae* (Tucker) Gordon (Tucker, 1927). The disease is also reported to be caused by *Fusarium batatis* Wollen var. *vanillae (*Childers and Cibes 1947*)*.

Management

Cultural practices such as providing adequate drainage, shade regulation to avoid excessive exposure and over shading, mulching the plant base irrigation during drought period etc. are recommended for the management of this disease.

Among the various species, *Vanilla planifolia* is found to be more susceptible while *V. pompona, V. phaentha* and *V. barbellata* are reported to be resistant to the pathogen.

Application of fungicides such as carbendazim 0.2% is effective in reducing the disease incidence if done in the initial stages of infection (Huang & Zheng 1991).

***Sclerotium* root rot**

The disease is characterized by the rotting of root tips. The infection starts at the root tips in the form of rotting which extend upwards resulting in drying of the entire roots. Affected vines show yellowing and wilting symptoms. In severely affected plants, the whole root system is damaged resulting in vine death (Joseph Thomas & Suseela Bhai (2002). The disease appears during the pre-monsoon period.

Causal organism

The disease is caused by *Sclerotium rolfsii.* During the infection phase, the fungus colonizes the roots, root zone soils and produce abundant thick white mycelial growth together with numerous globular brown coloured sclerotia, the fruiting body of the pathogen

Management

The disease can be controlled by soil drenching with 0.2% Carbendazim or 0.2% Copper oxychloride.

***Phytophthora* bean rot**

In India the disease was noticed in many vanilla plantations of Karnataka and Kerala (Suseela Bhai and Joseph Thomas, 2000). Disease appears during the onset of south west monsoon rains.

Symptoms

The symptom of the disease mainly appears as rotting of beans. Rotting usually begins from the bean tips and extends to the stalk Rotting starts on individual beans or among all beans in a bunch. In some cases, rotting starts from the pedicel region and progresses towards the tip. The infected portions of the beans are water soaked soft and dark brown. The fully infected bunch fall off in 10-15 days emitting a foul smell, In advanced stages of infection, the rotting extends to the stem and leaves also. (Suseela Bhai & Joseph Thomas 2000).

Causal Organism

The disease is caused by *Phytophthora meadii* Mc Rae.

Management

The disease can be managed by adopting phytosanitory measures such as

1. Removal and destruction of infected plant parts to reduce the inoculum build up.
2. Regulation of shade during monsoon season in order to prevent excess shade (Allow at least 30-50 % light to fall on the vines)
3. Spray the foliage with 1% Bordeaux mixture and drench the base of the plant with 0.25% copper oxy chloride twice depending on the severity of infection and as prophylactic measure.

Sclerotium bean rot

Symptoms

The symptoms appear as rotting of bean tips that proceed towards the pedicel regions. Affected beans show thick white colored mats of fungal mycelium forming a mantle around the fruit bunch. Protruding hyphal strands grow abundantly on bean surface. White threads of fungal hyphae run longitudinally on the leaves, stem and beans

Causal organism

The disease is caused by Sclerotium *rolfsii*

Management

The disease can be managed by soil drenching and spraying with Carbendazim (0.2%) or Carbendazim –mancozeb mixture (0.25%) twice at 15 days' interval. (Joseph Thomas & Suseela Bhai 1999)

Viral diseases

Viral diseases are of common occurrence in all countries including India where vanilla is grown on a commercial scale.

Cucumber mosaic virus (CMV)
Cymbidium mosaic virus (CyMV)
Odentoglossum ring spot virus
Vanilla mosaic virus (VMV) and
Vanilla necrosis virus (VNV)

In India though the commercial cultivation of vanilla started only very recently, the occurrence

of virus diseases are on the higher side. 'Leaf curl' and Cymbidium Mosaic *Potexvirus* infections on *V. planifolia* was reported from the state of Karnataka. (Sudharshan *et al.,* 2003).
A survey conducted in 65 vanilla plantations in 28 locations of Karnataka and Kerala revealed the occurrence of two main virus diseases namely Mosaic and stem necrosis with an average incidence ranging from 0-5% and 0-10% respectively (Bhat *et al.,* 2003., 2004a, b) was again reported from Karnataka and Kerala.

Transmission and spread

Almost all the known viral diseases of vanilla are sap transmissible and are easily spread through stem cuttings. Once the plant is infected with viruses, it is almost impossible to eliminate them. More over survival of infected plants in the garden enhances further spread of the disease to other healthy vines. The major means of spread of the virus is through the use of infected stem cuttings. Insects may also play an important role in the transmission and spread of the disease in nature.

Management

There are no chemical control measures as such for any viral infections on plants. Spread can be prevented by adopting plant protection measures as described below.
1. Use of virus-free planting material is the first and foremost requirement to check the spread of the virus. Apparently healthy plants should not be used for any new planting .as this would carry the virus which eventually would show the disease symptoms after planting.
2. If tissue culture raised plants are used, it is important to check for the presence of virus in the mother plant. If the mother plant is infected with the virus, the plantlets derived from this also will carry the virus thus contributing for the spread of the virus.

3. Regular disease surveys should be carried out to identify the plants showing viral symptoms of viral infection. Such infected vines should be removed and destroyed in order to avoid further disease spread. Wisler *et al*., (1987) suggested to practice regular rouging of virus infected vines as a control measure.

Insect pests of vanilla

Vanilla is reported to be affected by a few numbers of pests, but the damage caused is not very severe. (Purseglove *et al.,* 1981). Among the insect pests that cause considerable damage to vanilla, hemipteran bug, lepidopteron caterpillar and a coleopteran weevil are most important.

Vanilla bug: *Halyomorpha picus* F. (Pentatomidae), is called the vanilla bug. It causes serious damage by sucking the sap from shoot tip and inflorescence. Prakash and Sudharshan (2002) reported this pest for the first time on vanilla in India. The damage caused by this bug is characterized by the appearance of pin-prick-like punctures at the site of feeding. This is followed by necrosis and rotting of the inflorescence /shoot tip. It is reported from many parts of

Kerala and Karnataka. The bug is reported to occur in areas where vanilla is intercropped with arecanut. The pest incidence was high during inflorescence initiation period during January-February months. Management practices includes monitoring the bug during November to February and removal of egg mass and first instar nymphs which are seen on the lower surface of leaves. Spray Monocrotophos at 0.075 % a.i. or Karate 40ml/100liter controls the nymphs (Personal communication).

Scale insects (unidentified) (Coccidae)

The occurrence of the insect is noticed during January-February months. This insect is prevalent in Idukki district of Kerala (Varadarasan et al., 2002 b). It sucks the sap from the leaves, vine and inflorescence. Black ants are found to be associated with this sucking insect. Spray Monocrotophos at 0.075% a.i., if the pest incidence is serious.

Emrald bug

Nezara smargdula (Fabr.) and *N. viridula* (Pentatomidae): These bugs occur throughout the tropics. The bugs lay eggs on leaves and stalks, the nymphs suck the sap of flower buds and stalks. Occurrence *N. viridula* is reported on vanilla in Karnataka and Kerala, but the incidence is very low (Varadarasan *et al*., 2003).

Vanilla vine weevil, Sipalus sp. (Dryopthoridae: Coleoptera)

The pest is reported to cause serious damage to young shoots, vines and leaves of vanilla in Idukki district of Kerala, India. The adult weevil feeds on vegetative shoot leading to necrosis and are seen in the fields from November-January (Fig. 8b). Since the weevil lays eggs singly along the length of the vine and the emerging grubs feeds the inner core of the stem by making tunnel, the entire length of vine become pieces, rot and fall down (Varadarasan, *et al*., 2002). . The weevil also feeds on leaves by scrapping upper or lower epidermis with mesophyll tissue, leaving a thin transparent epidermis on the lower or upper surface of leaves. (Varadarasan et al., 2002a). The weevils are not very active, and hence they may be hand picked and destroyed to reduce the damage on crop (Varadarasan *et al.,* 2002a).

***Plusia* sp. (Noctuidae)**

The caterpillar of the moth feeds on the vegetative shoots. The pale green caterpillars are seen in between the shoot bud and the first leaf, forming web and feeding the shoot which leads to rotting of the terminal bud. These pests are noticed in many vanilla growing tracts of Kerala viz. Idukki, Kottayam, Ernakulam and Thrissur district. Incidence was recorded in January and February months. The pest may be controlled by spraying Monocrotophos at 0.075% a.i. if the incidence is high (Anonymous, 1996).

Pollination and Fruit set

Fruit set is achieved by artificially pollinating each flower by hand. Botanically, fruit of vanilla is capsule and is popular in the trade as a bean. Fruit is pendulous, narrowly cylindrical, obscurely three angled, 10-25 cm long and 5-15 mm in diameter. The fruits are aromatic on processing and drying. Each fruit contains myriads of very minute globose seeds of about 0.3 mm in diameter on ripening. Seeds are liberated by the longitudinal splitting of the capsule along three lines at maturity. In commercial production the capsules are harvested before they start ripening.

The vanilla bean contains thousands of seeds which fail to germinate under natural conditions. Seed germination in vanilla is possible under artificial conditions *in vitro* using a variety of culture media. Successful establishment of seedling progenies in the field is also standardized (Mary et al 1999). This is helpful for the utilization of genetic variability available among the segregating seedling progenies for crop improvement and induction of variability through intra and inter-specific hybridization and *in vitro* mutagenesis.

Pollination

Vanilla planifolia usually flowers only once in a year over a period of about 2-3 months. In India the peak flowering period is during January to March. There may be slight variations in each year depending upon seasonal changes. Irrespective of the fact that vanilla flower is self-fertile the floral architecture of vanilla is such that natural self-pollination is impossible, due to the separation of anther from stigma by the rostellum. A pollinating agent is essential for transferring pollen from anther to stigma. In Mexico and Central America, where vanilla is indigenous some of the flowers are pollinated by the bees of the genus *Melipona* and also by hummingbirds (Ridley 1912, Purseglove *et al.* 1981). Elsewhere hand pollination is unavoidable for fruit set. Childers and Cibes (1948) expressed doubt about the role of bees and humming birds on natural pollination and later Childers *et al.* (1959) said that there is no experimental proof that they are effective pollinators.

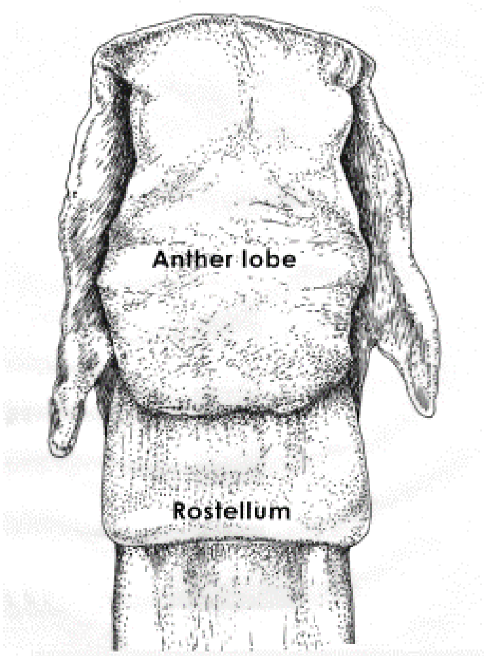
Even in Mexico natural fruit set is very low and hand pollination is practiced in commercial cultivation. In Puerto Rico, natural pollination was about 1 percent (Childers and Cibes 1948). Thus, flowers are to be hand-pollinated to achieve fruit set. The method of hand pollination was discovered by Morren in Liege in 1836, and Edmund Albius a former slave in Reunion, discovered a practical method of artificial pollination in 1841, which is still practiced for commercial production of vanilla fruits.

The flower opens early in the morning and closes in the afternoon, and never reopens. They are receptive for eight hours and wither the following day (Purseglove *et al.* 1981). The optimum time for pollination is in midmorning (Childers *et al.* 1959). According to Shadakshari *et al.* (2003) flower of vanilla opens at 6.00 AM and stigma is receptive 41 h before complete flower opening and 17 h after complete flower opening under hill zone conditions of India. Pollen is viable since 23 h before complete flower opening and 16 h 30 m after complete flower opening. Bhat and Sudharshan (1998) obtained maximum fruit setting percentage when pollinated at 8.00

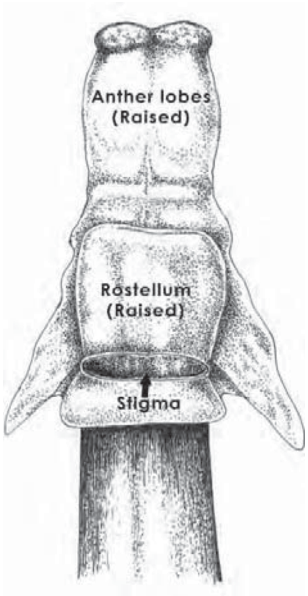
AM and according to them the ideal time for pollinating vanilla is between 6.00 AM and 1.00 PM.

Hand pollination:

Hand pollination is done with a splinter of bamboo or other material about the size of a tooth pick. The flower is held in one hand and the labellum is pushed down with the thumb releasing the column. The anther cap is removed by the stick which is held in the other hand which exposes the pollen mass. Then the flap-like rostellum is pushed up under the anther and with the stick and, by pressing with the thumb and the finger, the pollinia are brought into contact with the sticky stigma to which the pollen mass adheres. Different stages of pollination are demonstrated in Fig.4.



Front view of column showing anther and rostellum



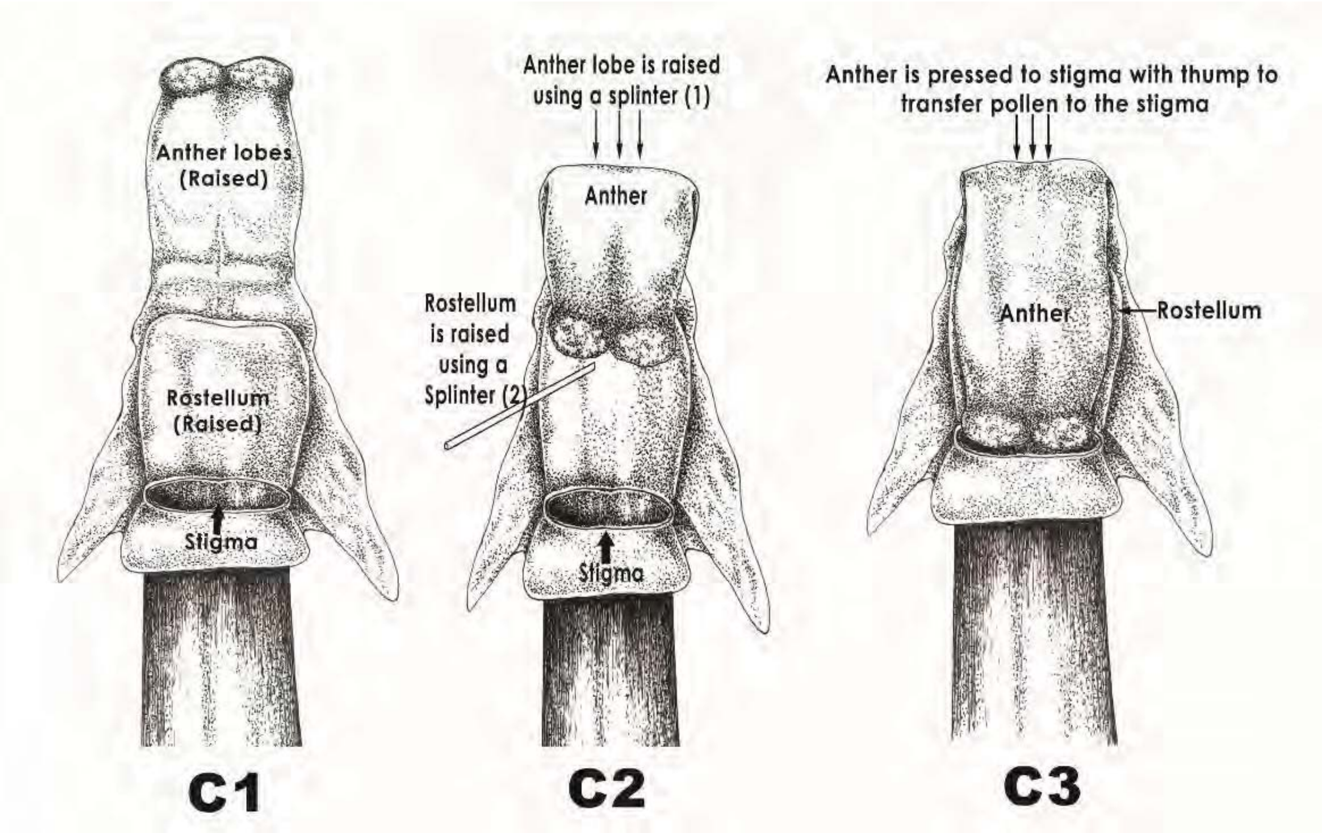
Front view of column with rostellum and anther lobes raised

Fig. 4 Different stages of pollination

Harvesting and yields

The period of time between flowering and harvesting is 6 - 9 months. The pods are harvested rotationally when they are fully grown and as they begin to ripen, as shown by the tips becoming yellow. It is essential to pick to pods at the right stage as immature pods produce an inferior product and if picked too late they will split during curing. The plantations should be visited daily so that the pods can be picked as soon as they are ready. They may be harvested by

Home



sideways pressure of the thumb at the base or by cutting with a sharp knife. About 6 kg of green pods produce 1 kg of cured beans. Curing should begin within a week of harvesting the beans. Yields are very variable. A good vanillery is said to yield about 500 - 800 kilograms of cured beans per hectare per annum during a crop life is about 7 years.

Curing of vanilla beans

The primary quality determinant for cured vanilla beans is the aroma/flavor character. Other factors of significance in quality assessment are the general appearance, flexibility, the length and the vanillin content. The relative importance of these various quality attributes is dependent upon the intended end-use of the cured beans. Traditionally, the appearance, flexibility and size characteristics have been of importance since there is a fairly close relationship between these factors and the aroma/flavor quality. Top-quality beans are long, fleshy, supple, very dark brown to black in color, somewhat oily in appearance, strongly aromatic and free from scars and blemishes. Low-quality beans are usually hard, dry, thin, brown or reddish-brown in color and possess a poor aroma.

At one time, the presence of a surface coating of naturally exceeded vanillin crystals (frosting) was regarded as an indicator of good quality. However, this is no real guide and Mexican vanilla, which has the best reputation for quality, rarely "frosts". A high vanillin content is desirable but this value is not directly commensurate with the overall aroma/flavor quality of the bean. Much of the vanilla entering Western markets is used for the preparation of vanilla extract, and for this purpose the appearance of the beans is not of prime importance.

Traditional curing methods

A number of procedures have been evolved for the curing of vanilla, but they are all characterized by four phases.

Killing or wilting:

This stops further vegetative development in the fresh bean and initiates the onset of enzymatic reactions responsible for the production of the aroma and flavor. Killing is indicated by the development of a brown coloration in the bean.

Sweating

This involves raising the temperature of the killed beans to promote the desired enzymatic reactions and to provide a first, fairly rapid drying to prevent harmful fermentation. During this operation, the beans acquire a deeper brown coloration and become quite supple, and the development of an aroma become perceptible.

Drying:

The third stage entails slow drying at ambient temperature, usually in the shade, until the beans have reached about one third of their original weight.

Conditioning

In the final stage, known as "conditioning", the beans are stored in closed boxes for a period of three months or longer to permit the full development of the desired aroma and flavor.

Various traditional procedures for curing vanilla beans are known all over the world (Mexican method, Tahitian method, artificial method). But, the most important one used in Indian Ocean islands (Madagascar, Comoros, Reunion) and also in Indonesia is **"the Bourbon"** method. In Indonesia, from place to place the Bourbon method or the Mexican method or sometime an adaptation of both methods is used accordingly with the various geographic and weather conditions.

The Bourbon method

● On arrival at the curing factory, the beans are sorted according to the degree of maturity, size, and into split and un-split types.

● Batches of beans, weighing 25 - 30 kg, are loaded into open-work cylindrical baskets which are then plunged into containers full of hot water heated to 60 - 63 degrees Celsius, over a wood fire.

● Batches of beans which will eventually make up the top three qualities are immersed for 2 - 3 minutes, while smaller and split beans are treated for less than 2 minutes.

●The warm beans are rapidly drained, wrapped in a dark cotton cloth and are placed in a cloth lined sweating box.

●After 24 hours, the beans are removed and inspected to separate those which have not been properly killed.

●The next stage of sun-drying is carried out on a plot of dry, easily drained ground, at some distance from roads to avoid contamination by dust. The killed beans are spread out on dark cloths resting on slatted platforms, constructed from bamboo and raised 70 cm above the ground. After one hour of direct exposure to the sun, the edges of the cloth are flooded over the beans to retain the heat.

●The cloth-covered beans are then left for a further two hours in the sun before the blanket is rolled up and taken indoors.

●This procedure is repeated for 6 - 8 days until the beans become quite supple.

●The third stage involves slow drying in the shade for a period of 2 - 3 months.

●The beans are spread on racks, mounted on supports and are spaced 12 cm apart in a well-ventilated room.

●During this slow drying operation, the beans are sorted regularly and those which have dried to the requisite moisture content are immediately removed for conditioning.

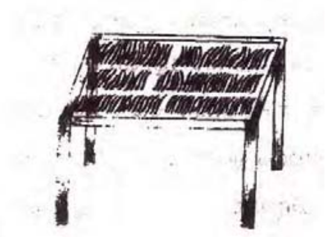
In some localities in Madagascar and most commonly in Indonesia where the weather is frequently inclement during the sun and indoor-drying periods of curing, ovens set at 45 - 50 degrees Celsius have traditionally been used. Conditioning of the beans is carried out in a similar manner in Madagascar and Mexico and takes about 3 months for completion. The overall curing process for Bourbon vanilla lasts 5 - 8 months. The main harvesting season in Madagascar extends from June to early October.

Grading and packaging

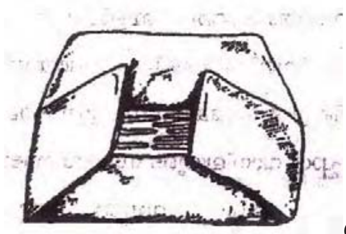
After conditioning, the cured beans are given an airing and are re-straightened by drawing through the fingers. The beans are then subjected to a final sorting into grades and according to their length, prior to bundling and packaging for shipment. The length of the beans is an important determinant of the price which the whole beans will fetch. Grading system differ somewhat between producing countries, but beans are generally classified into three categories: unsplit beans, split beans and "cuts". The last type has traditionally consisted of beans which have been attacked by mold and have had the infected portion cut away. Very small and broken beans of poor aroma quality are usually combined with the "cuts" from moldy beans. It should be noted, however, that the ‘cuts’ do not always consist of entirely of poor quality beans. In Mexico, "cuts" usually comprise 10 - 20 percent of production in a normal year but, in years of good prices, the smaller curing firms would often cut all their beans prior to curing because drying times were shortened. Also, the artificially dried cut beans which have entered the market in recent years are of a good aroma and flavor quality and are produced specifically for extraction. Different stages of processing are shown in Fig. 5,6 and 7.

Fig.5 Vanilla beans after killing by hot water treatment

A



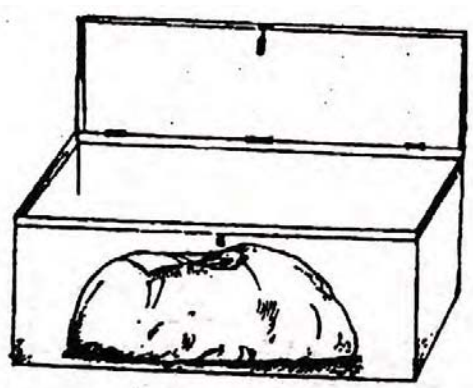
B



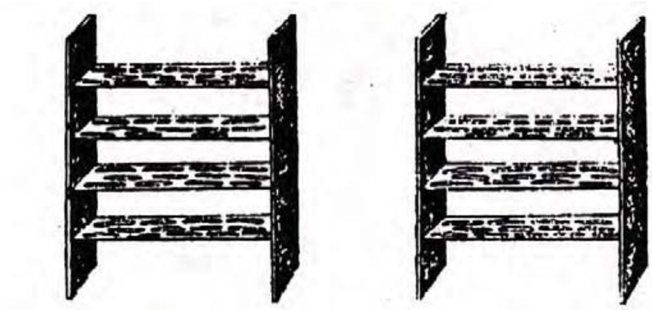
C

Fig. 6 Different stages of vanilla processing-1

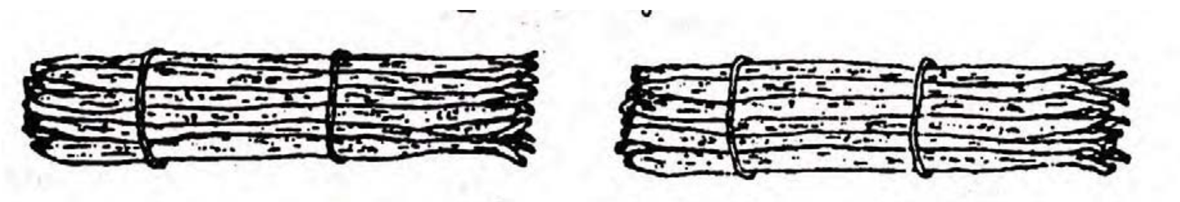
A. Killing **B.** Sun Drying, **C.** Wrapping



A



B



D

Fig. 7 Different stages of vanilla processing-2

A. Sweating inside the wooden box B. Slow drying indoor C. Making bundles after conditioning

Conclusion and future thrusts

The natural vanilla production and its consumption are being increased steadily, worldwide. But this fascinating natural flavor continues to be a costlier one. This is due to high cost of production of the natural product. The high cost will force the users to either reduce the consumption or accept synthetic substitutes which are cheaper. Thus, any research effort on vanilla should be oriented to reduce the cost of production and thereby cost of product. This will encourage more users to select the natural product which is essential for a sustainable progress in vanilla cultivation.

It has been indicated that traits like self-pollination, root-rot resistance, ability to maintain higher fruit sets, and less dependence of flower induction to photo period, could be desirable characters in vanilla as a crop (Soto Arenas 1999). Thus the research efforts should be oriented to achieve these goals.

The most labor-intensive process in vanilla cultivation is the hand-pollination for commercial production. The natural self-pollination can be achieved by reducing the size of rostellum which prevents the contact between anther and stigma in vanilla flower. Use of induced mutations to produce a variety with reduced rostellum can be examined. Interspecific hybridization and subsequent back crosses with self- pollinating species like *V. wightiana* may also be examined to solve this problem.

It is evident that only very few studies have been conducted on nutritional requirement, physiology of growth and flowering. Thus research on nutritional requirement of vanilla at different stages of production and production physiology should be priorities.

Disease and pest control through biocontrol agents and botanicals should be of priority in plant protection research in vanilla. Such efforts will help a greater extent in organic farming of vanilla also. The future of vanilla cultivation depends on how effectively we adopt organic cultivation practices.

The lengthy time required for processing of beans is a serious handicap. Reducing the processing time without deterioration of quality will be a challenge for postharvest technologists.

Transfer of Technology & Extension for Spices Development- Institutions & Programmes

P. Rajeev

ICAR-Indian Institute of Spices Research, PO Marikunnu, Kozhikode – 673012

India produces a wide range of spices. At present, production is around 3.2 million tonnes of different spices valued at approximately 4 billion US $, and holds a prominent position in world spice production. Because of the varying climates - from tropical to sub-tropical to temperate- almost all spices grow splendidly in India. In reality almost all the states and union territories of India grow one or the other spices. Under the act of Parliament, a total of 52 spices are brought under the purview of commercially cultivated spice .however 109 spices are notified in the ISO list.

India is the largest producer, exporter as well as consumer of spices. Some spices Indian Institute of Spices Research, a premier research institute under ICAR deals with seven tropical spices. These are Black pepper, Small cardamom, Ginger, Turmeric, Nutmeg, Cinnamon, Clove, Vanilla and Garcinia. Black pepper and cardamom are mainly cultivated as a cash crop in Western Ghats belt and being raised on a plantation scale, these crops support a sizeable proportion of farming community and agriculture labour. These crops essentially form a part of Coffee and Tea plantations in South India region.

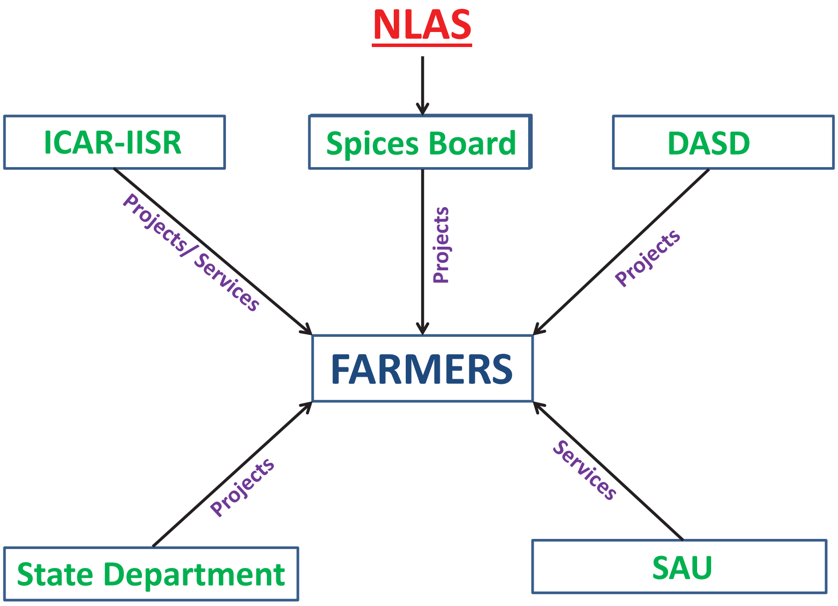
Adoption of scientific technologies by farmers per se as well as institutional role in TOT and extension for spice sector development are influenced by two important factors. Firstly these crops are high value crops and secondly they are classified as commodities of trade because of their share in the export basket of the country.

The adoption behavior, the diffusion of scientific technologies and the extension services in vogue can be defined as '**demand driven**" and "**market lead".** This because, investment in the farming sector is greatly influenced by high price volatility of most of the spices. The price instability could be attributed to the changes in global supply during the post liberalization period, with many new entrants in the production and trade scenario like Vietnam and Thailand in case of black pepper and Guatemala in case of cardamom and other factors like fluctuations in production.

Extension programmes for Spices -Institutional framework

The state Department of Agriculture is the major player in providing extension services. As per provisions in the state plan as well as Central aided project funds the department offers field extension services in spices for the farmers. Some programmes are also implemented through Panchayat Raj Institutions (PRI). The state Agricultural Universities through their extension projects offers educational, information and communication services to farmers. Indian Institute of Spices Research under ICAR implements front line extension services through planned projects. Two major National Level Agencies (NLA) offering development services to spice growing farmers are Spices Board under the Ministry of Commerce of Government of India and Directorate of Arecanut and Spices Development under the Ministry of Agriculture and Cooperation, GOI.. The national Extension system for spices is depicted in figure 1.

Figure 1 National Extension System-Spices



I. ICAR Institutional mechanisms for TOT

ICAR provides extension services to farmers and other stake holders through two institutions.

Agriculture Technology Information Centre (ATIC)-A single window delivery mechanism for technology products and services

Krishi Vigyan Kendras(KVK) established in all districts

1. Agriculture Technology Information Center (ATIC)

The importance of an appropriate information package and its dissemination as an input has assumed added emphasis in this “information age”. The kind of information and the way it is to be used are critical factor to the growth of agriculture. It is also worth noting that it is no longer enough for research to generate information alone. The required information is also to be delivered to the end user at one place. This information must be direct, clear and easily understandable and without any room for distortion.

There is a greater need for coordination between researchers and technology users. A higher degree of integration needs to be achieved by having a formal management mechanism linking scientists or department in charges of different disciplines (though engaged in interdependent tasks) on the one hand to the technology users on the other. The linkage mechanism should be with formal, permanent, mandated, facilitated and designated function. The establishment of an agricultural Technology Information Centre will provide such a mechanism beyond the individual unit of a research institution to contribute to the dissemination of the information. This will serve as a single window delivery system for services and products of research for the areas in which the concerned institute is involved.

The cornerstone of India's agricultural revolution has been the availability of improved varieties of cereals, oilseeds, pulses, etc. breed of livestock including poultry and fisheries; horticultural plant materials, and improve management practice for increase productivity, sustainability and stability of various crops and livestock enterprises. This has raised the search by farmers for future availability of seed, planting materials and other materials, easy accessibility to diagnostic services for soil fertility and plant protection, availability of appropriate information through leaflets and pamphlets and increased scope in sale of consultancy services. Often the farmers are not aware as to whom and where to approach for field problems. It is felt that the facility of a **'single window'** approach at the entrance of the ICAR Institute/State Agricultural Universities will enable the farmers to have the required information for the solution to their problems related to the areas in which the concerned institute is involved. Because of the dominance of small and resource poor farmers and concentration of poor people in several sectors, public institutions like ICAR institutes and SAU's will continue to play a vital role in supply of information for increasing the overall productivity in agriculture.

The rationale for establishment of ATIC are

1. To provide diagnostic services for soil and water testing, plant and livestock health.

2. To supply research products such as seeds and other planning materials, poultry strains, livestock breeds, fish seed, processed products, etc, emerging form the institution for testing and adaptation by various clientele.

3. Providing information through published literature and communication materials as well as audio—visual aids.

4. Providing an opportunity to the institutes/SAU/s to generate some resource through the sale of their technologies.

The important criteria of Agricultural Technology Information are

1. Availability (or accessibility) of new technologies,

2. Relevance of new technologies;

3. Responsiveness of new technologies to the needs of different categories of farmers; and

4. Sustainability of such unit within the overall institutional system

The Agricultural Technology Information Centre (ATIC) is a "single window" support system lining the various units of a research institution with intermediary users and end users (farmers) in decision making and problem solving exercise.

By building on the past investment in infrastructures in these institutions considerable farm worthy techniques/ technologies/ knowledge material have been developed in the institutions which can provide the techniques, technologies, seeds and planting materials to the farmers and other organizations for taking up the frontier technologies, to the field. This will facilitate in dealing effectively with the complexity and diversity of information system and channels. Such information will be useful for:

1. Farmers;
2. Farmer-entrepreneurs;
3. Extension workers and development agencies;
4. NGOs; and
5. Private sector organization.

These centers will provide a 'balanced scorecard' in terms of

1. Financial- Resource generation and financial sustainability
2. Customers-measures on performance of the technology from the customer's point of view
3. Process- the performance of key internal processes in terms of providing quality services, seed and plant materials, etc. linkage with district extension system and, spread of improved technology and productivity in the area
4. Learning- the ability of the research organization to improve continuously and innovate in its products, services and processes.

Objectives:

The objectives for establishment of such centers as a single window system are as follows:

1. To provide a 'single window' delivery system for the products and species available form an institution to the farmers and other interested groups as process of innovativeness in Technology Dissemination at the institute level.
2. To facilitate direct the farmers access to the institutional resources available in terms of technology, advice, technology products, etc. for reducing technology dissemination losses
3. To provide mechanism for feedback from the users to the institute

2. KVK System: Mandate and Activities

The first KVK was established in 1974 at Puducherry. The number of KVKs has risen to 645 and 106 more KVKs are to be established in the newly created districts and some larger districts. The KVK scheme is 100% financed by Govt. of India and the KVKs are sanctioned to Agricultural Universities, ICAR institutes, related Government Departments and Non Government Organizations (NGOs) working in Agriculture.

KVK, is an integral part of the National Agricultural Research System (NARS), aims at assessment of location specific technology modules in agriculture and allied enterprises, through technology assessment, refinement and demonstrations. KVKs have been functioning as Knowledge and Resource Centre of agricultural technology supporting initiatives of public, private and voluntary sector for improving the agricultural economy of the district and are linking the NARS with extension system and farmers.

The mandate of KVK is **Technology Assessment and Demonstration** for its **Application** and **Capacity Development**.

1. To implement the mandate effectively, the following activities are envisaged for each KVK
2. On-farm testing to assess the location specificity of agricultural technologies under various farming systems.
3. Frontline demonstrations to establish production potential of technologies on the farmers' fields.
4. Capacity development of farmers and extension personnel to update their knowledge and skills on modern agricultural technologies.
5. To work as Knowledge and Resource Centre of agricultural technologies for supporting initiatives of public, private and voluntary sector in improving the agricultural economy of the district.
6. Provide farm advisories using ICT and other media means on varied subjects of interest to farmers

In addition, KVKs produce quality technological products (seed, planting material, bio-agents, livestock) and make it available to farmers, organize frontline extension activities, identify and document selected farm innovations and converge with ongoing schemes and programs within the mandate of KVK.

Spices Board: Projects and Strategy

1. Export Oriented Production Programmes

The Spices Board is implementing the XII plan programmes for development of cardamom (small & large) and post-harvest improvement of other spices under the head Export Oriented Production. Export Oriented Production is broadly divided into

• Production improvement programmes meant for small & large cardamom
• Post-Harvest improvement as a part of quality improvement of spices for export
• Extension support for both the above programmes.

These programmes mainly covers two crops, small cardamom and large cardamom. The strategy is to popularize and facilitate adoption of improved technologies like quality planting material, Good Agricultural Practices (GAP) kits, mechanization on both on farm and for post harvest operations and irrigation and land development. All the programmes are subsidy linked.

The Board also have a "target area" programme for North Eastern states operating progarmmes New planting ,Production of Planting materials through Certified Nurseries For making available quality planting materials,. Curing Houses (Modified Bhatti) ,Construction of Irrigation Structures, Mechanisation, Cultivation of Lakadong Turmeric ,Cultivation of NE Ginger and training of extension functionaries and farmers of North east.

The Board also is implementing Post harvest improvement programmes for other spices for popularizing available technologies like Seed spice thresher, Pepper thresher ,Bamboo mats ,Turmeric polisher , IPM kits for Chilli , polythene/silpauline sheets for drying ,Mint distillation unit ,Pepper/clove ladders for harvesting ,Spice cleaners/graders ,Tamarind/nut meg dehuller , Nutmeg driers. Packing and storage unit for garlic, Herbal spice extractors & Dehydration units ,Dry/fresh ginger peeling & storage unit ,Seed spice cleaning & storage unit and Spice Washing Equipment

2. Programmes for Export Development and Promotion

INFRASTRUCTURE DEVELOPMENT SCHEME (IDS) is a high end scheme which prides three components.

1. Adoption of Hi-Tech in Spice Processing.
(2) Technology and Process Upgradation.
(3) Setting-up/up-gradation of in-house quality control laboratory.
(4a) Quality certification such as ISO 22000, SQF 2000, GMP traceability, FDA Registration
(4b) Validation of check samples and training of laboratory personnel.

For Hi tech Spice processing, Technology/Process up gradation and setting up of in house quality control lab, grants are given by the board based on clear guidelines and norms for purchase and establishment of machinery/ equipment's.

3. Quality Evaluation Laboratories

The first Quality Evaluation Laboratory (QEL) of Spices Board was established in 1989 at Cochin. It is certified under the ISO 9002:1994 Quality Management System in 1997 and upgraded to ISO 9001: 2008 in 2009. And ISO 14001: 1996 Environmental Management System in 1999 and upgraded to 14001: 2004 Environmental Management System in 2006 by the British Standards Institution, U.K. It is also accredited under ISO/IEC: 17025 in September 2004 by the National Accreditation Board for Testing & Calibration Laboratories (NABL), Department of Science & Technology, Govt. of India. As a part of providing speedy analytical services to exporters, Spices Board has established Regional Quality Evaluation laboratories at the major producing / Exporting centers Viz. Chennai, Guntur, Mumbai, New Delhi and Tuticorin. The construction work of the Laboratory at Kandla is being completed and Kolkata is in progress. The laboratories at Mumbai, Guntur and Chennai are also got NABL (ISO/IEC: 17025) accreditation and the other laboratories are in the process of getting the same. The Laboratory provides analytical services to the Indian Spice Industry and monitors the quality of spices produced and processed in the country. It also undertakes analysis of consignment samples under the mandatory inspection of Spices Board. It has facilities to analyze various physical, chemical and microbial parameters including pesticide residues, mycotoxins, heavy metals, illegal dyes like Sudan I-IV, Para Red, Rhodamine B, Butter Yellow, Sudan Red 7B, Sudan Orange G etc, and contaminants/adulterants in spices and spice products.

4.Spices Park

To empower the growers of spices and ensure better price realization, Board has taken steps to establish spices Parks at the seven locations to provide scientific infrastructure facilities. The projects on Spices Park are primarily intended to benefit the growing community through quality improvement, grading, packing, warehousing, etc for value addition which would lead to better price realization of their produce. The exporters can also set up their unit in the Parks for processing spices under the terms and conditions of the Board. **The programme is an illustration of PPP mode**. The centers where Spices Parks proposed are:

a) Chhindwara [Madhya Pradesh]
b) Puttady [Kerala]
c) Guntur [Andhra Pradesh]
d) Sivaganga [Tamil Nadu]
e) Jodhpur [Rajasthan]
f) Mehsana [Gujarat]
g) Kota [Rajastan]
h) Guna [Madhya Pradesh]

III.Directorate of Arecanut and Spices Development-Projects and Strategies

The Directorate of Arecanut and Spices Development, Calicut, a subordinate office under the Ministry of Agriculture, has the national mandate for the development of arecanut, spices other than cardamoms and aromatic plants. The Directorate implements Central Sector /Centrally Sponsored Schemes for development of these crops at National level. Since the launch of National Horticulture Mission (NHM) programmes in the country from 2005-06, the Directorate was entrusted with the responsibility of coordinating and monitoring the mission programmes assigned to various State Governments on the mandate crops. In addition, the Directorate directly implements certain programmes such as production of nucleus planting materials of high yielding varieties, technology transfer through frontline demonstration plots, National Seminar / Workshops, Farmers Training etc.

During 2014-15, the Directorate implemented MIDH programmes with an outlay of Rs 1100.00 lakhs under the mandated Mission for Integrated Development of Horticulture (MIDH). As per the guidelines, the programme operates on a **Mission Mode** with an **End to End Approach,** reaching the farmers directlyu The Directorate is continuing the programmes taken up during 2014-15, with a few additions in 2015-16. The programmes will be implemented in association with State Agricultural Universities (SAUs), Indian Council of Agricultural Research (ICAR) Institutes and reputed NGOs across the country with an outlay of Rs 1100.00 lakhs during 2015-16. The proposed programmes cover the following domains**.**

1. Production and distribution of nucleus planting materials
2. Accreditation of Spices Nurseries
3. Technology Dissemination through Frontline Demonstration
4. Innovative Programmes
5. Transfer of technology programmes like training, semnars etc.

State government –Projects and Strategies

The **Sugandhi Pepper Rehabilitation Programme** and **Pepper Development Programme for North Kerala** are sate sponsored projects. The projects are operating on a **'Consortium**' mode involving, SAU, IISR and State Department.These comprises of programmes for establishment of decentralized nurseries, assistance for planting of new standards, establishment of demonstration plots and revitalization of Pepper Samithies or Farmers groups. Production and supply of bio control agents. Major functional components are

1. Expert team members for the diagnostic field visits
2. Collection and transportation of soil samples for analysis
3. Conducting participatory rural approaches and workshops
4. Compilation of the soil analysis results and preparation and distribution of pepper health cards
5. Importing training to farmers at various levels
6. Conducting FLD's and feed back

Home

TECHNOLOGIES FOR COMMERCIALIZATION

By
Institute Technology Management - Business Planning & Development Unit
ICAR - Indian Institute of Spices Research,
Marikunnu PO, Kozhikode, Kerala-673012

ABOUT ICAR-IISR

Intensive research on spices in the country was initiated with the establishment of a Regional Station of Central Plantation Crops Research Institute (CPCRI) at Kozhikode, Kerala during 1975 by the Indian Council for Agricultural Research (ICAR). This regional station was upgraded as National Research Centre for Spices (NRCS) in 1986 and was further elevated to the present Indian Institute of Spices Research (IISR) during 1995.

IISR promotes entrepreneurship and technology commercialization for income generation of farmers and entrepreneurs. Several technologies developed at the institute have been licensed through the Institute Technology Management- Business Planning and Development (ITM-BPD) Unit. The unit also provides guidance in IPR protection of technologies.

ITM - BPD UNIT

The ITM-BPD Unit is an initiative of ICAR to promote entrepreneurship in agribusiness through technology development and commercialization. ITM-BPD Unit facilitates startups with access to agro-technologies, infrastructure, capacity building, handholding and to develop successful business ventures, market linkages.

Business Support Services

- Technology/product-development, know-how transfer, licensing
- Technical and scientific support
- Marketing support
- Business plan development
- Infrastructure support like office space, laboratory, greenhouses, processing and pilot facility etc.
- Legal and IP advisory
- Udhyog Aadhar Registration
- Patent search and Trade Mark registration

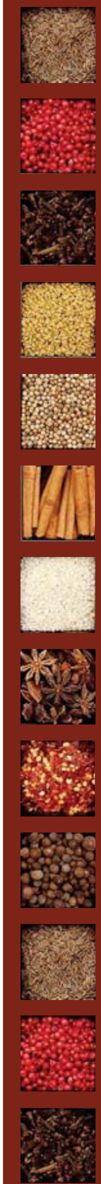
Office and incubation facility (ITM-BPD Unit)

I. IMPROVED VARIETIES OF SPICES

ICAR-IISR has released several high yielding and improved varieties of ginger, turmeric, cardamom, black pepper, nutmeg and cinnamon which have become very popular across the country. IISR Keralashree is the first nutmeg variety released through farmer's participatory breeding approach and the license fee from commercialization of this variety is shared on equal terms with the farmer. One of the cardamom varieties has secured registration from PPV & FRA.

IISR initiates issue of non-exclusive licensing from 2011 for commercial production of spice varieties. Healthy disease-free seed/ planting materials are provided to the licensees for commercial production of genetically pure planting materials. Currently we have 31 licensees for commercial production of plant varieties(Table-1). For availability of seed and planting materials, it is recommended to contact these licensees.

View of planting material production facility



BLACK PEPPER VARIETIES

Piper nigrum L.

IISR GIRIMUNDA

SALIENT FEATURES: Piperine 2.2%, oleoresin 9.65%, essential oil 3.4% and dry recovery 32.0%. Suited for high altitude (3000 ft msl) and plains

MARKET ASPECTS: Farmers/coffee tea planters,corporate firms with coffee and tea planations and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 2880 kg/ha (dry wt.)

Income generation: @ Rs.190/kg

Gross income : 5.47 lakhs /year/ha

Cost of production : Rs. 37.8/kg

Nurseries: Unit cost of Rs. 3.50 per cutting

IISR MALABAR EXCEL

SALIENT FEATURES: Oleoresin 11.7%, piperine 2.4%, essential oil 2.8%, dry recovery 32.3%. Suitable for high elevations & plains

MARKET ASPECTS: Farmers/coffee tea planters,corporate firms with coffee and tea planations and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 1453 kg/ha (dry)

Income generation: @Rs.190/kg dry wt,

Gross income: Rs. 2.76 lakhs/year /ha

Cost of production : Rs 37.8/kg

Nurseries: Unit cost of Rs. 3.50 per cutting

IISR THEVAM

SALIENT FEATURES: Piperine 1.6%, oleoresin 8.15%, essential oil 3.1% and dry recovery 32.5%, field tolerant to *Phytophthora* foot rot

MARKET ASPECTS:

Farmers/coffee tea planters,corporate firms with coffee and tea planations and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 2437 kg/ha (dry)

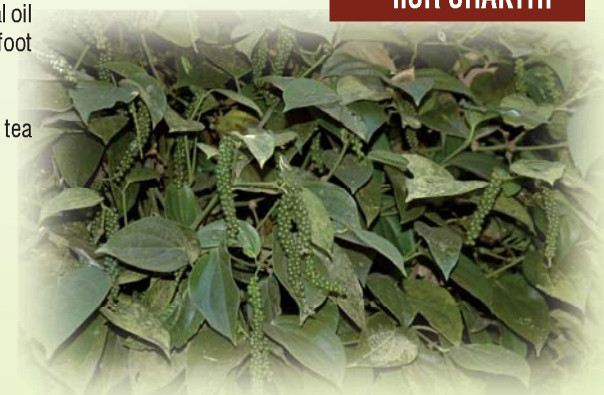
Income generation: @ Rs.190/kg

Gross income: 4.63 lakhs/year/ha

Cost of production : Rs. 37.8/kg

Nurseries: Unit cost of Rs. 3.50 per cutting

IISR SHAKTHI



SALIENT FEATURES: Piperine 3.3%, oleoresin 10.2%, essential oil 3.7% and driage 43.0%. *Phyophthora* tolerant line for managing foot rot disease in black pepper

MARKET ASPECTS:

Farmers/coffee tea planters, corporate firms with coffee and tea planations and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 2020 kg/ha (dry)

Income generation: @ Rs.190/kg

Gross income : 3.84 lakhs/year/ha

Cost of production : Rs. 37.8/kg

Nurseries: Unit cost of Rs. 3.50 per cutting

GINGER VARIETIES

Zingiber officinale Rosc.

IISR VARADA

SALIENT FEATURES: Suitable for growing all over India and has wide use in ginger candy industry. The variety has crude fibre 4.5%, oleoresin 6.7% and oil 1.8%.

MARKET ASPECTS: Farmers and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 22.6 t/ha (fresh) wt

Income generation: (fresh) @ Rs.30/kg wt

Gross income of 6.78 lakhs/year/ha

Income generation: (Dried) 4.68 tons/ha @ 207 Rs/kg gross income of 9.69 lakh rupees

Cost of production/ha Rs. 5.67 lakh

IISR REJATHA

SALIENT FEATURES: Suitable for growing all over the country. Essential oil 2.36%, oleoresin 6.3% ,crude fibre 4.0% & dry recovery 20.8%

MARKET ASPECTS: Farmers and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 22.4 t/ha (fresh) wt

Income generation: (fresh)@ Rs.30 per kg wt

Gross income : 6.72 lakhs/year/ha

Income generation: (Dried) 4.65 tons/ha @ 207 Rs/kg gross income of 9.62 lakh rupees

Cost of production/ha : Rs. 5.67 lakh

Nurseries: Unit cost Rs. 45/kg of seed rhizomes

IISR MAHIMA

SALIENT FEATURES: The variety is resistant to nematodes (*M.incognita* and *M.javanica*). plumpy bold rhizomes, essential oil 1.72%, oleoresin 4.5%, crude fibre 3.26% and dry recovery 23.0%.

MARKET ASPECTS: Farmers and industries are the prospective users

FINANCIAL ASPECTS:

Output capacity: 23.2 t/ha (fresh) wt.

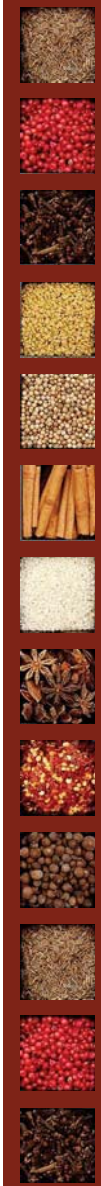
Income generation: @ Rs.30/kg (fresh) wt,

Gross income : 6.96 lakhs/year/ha

Income generation: Dried ginger 5.33 tons/ha @ 207 Rs/kg gross income of 11 lakhs rupees

Cost of production/ha : Rs. 5.67 lakh

Nurseries: Unit cost Rs. 45/kg of seed rhizomes



TURMERIC VARIETIES *Curcuma longa* L.

IISR PRABHA

SALIENT FEATURES: Curcumin 6.5%, oleoresin 15.0%, essential oil 6.5% and dry recovery 19.5%

MARKET ASPECTS: Suitable for curcumin extraction

FINANCIAL ASPECTS:

Output capacity: 39.12 t/ha

Income generation: 7.23 tons/ha (dry) @ 125 Rs/kg will lead to gross income of 9 lakh rupees

Cost of production/ha : Rs 5 lakhs

Nurseries: Unit cost Rs. 30/kg of seed rhizomes

Price of turmeric oil: Rs.1000-1500/kg

IISR PRATHIBHA

SALIENT FEATURES : Curcumin 6.2%,Oleoresin16.2%, Essential oil 6.2% & dry recovery 18.5%

MARKET ASPECTS: Suitable for curcumin extraction

FINANCIAL ASPECTS:

Output capacity: 39.12 t/ha

Cost benefit: Dry turmeric 7.23 tons/ha @ 125 Rs/kg, gross income of 9 lakh rupees

Cost of production/ha : Rs 5 lakhs

Nurseries: Unit cost Rs. 30/kg of seed rhizomes

Price of turmeric oil: Rs.1000-1500/kg.

IISR ALLEPPEY SUPREME

SALIENT FEATURES : Curcumin 5.55%, oleoresin 16.0% & dry recovery 19.0%

MARKET ASPECTS: Suitable for value added industries interested in curcumin extraction

FINANCIAL ASPECTS:

Output capacity: 35.4 t/ha

Cost benefit: Dry turmeric 6.72 tons/ha @ 125 Rs/kg will lead to gross income of Rs. 8.40 lakh

Cost of production/ha : Rs 5 lakhs

Nurseries: Unit cost Rs. 30/kg of seed rhizomes

Price of turmeric oil: Rs.1000-1500/kg

IISR KEDARAM

TECHNOLOGY BENEFITS: Curcumin 5.5% ,oleoresin13.6%, driage 18.9% & Tolerant to leaf blotch disease

MARKET ASPECTS: Suitable for curcumin extraction

FINANCIAL ASPECTS:

Output capacity: 34.5 t/ha fresh

Cost benefit: Dry turmeric 6.52 tons/ha @ 125 Rs/kg, gross income of 8.15 lakh rupees

Cost of production/ha : Rs 5 lakhs

Nurseries: Unit cost Rs. 30/kg of seed rhizomes

Price of turmeric oil: Rs.1000-1500/kg

IISR PRAGATI

High yielding new variety with average yield of 38 t/ha (fresh rhizomes). The yield can go up to 52 t/ha under favourable conditions. It has 30 % and 34% yield increase over national and local turmeric varieties. Short duration variety and takes only 180 days to harvest. Stable and high curcumin variety (5.02%) across locations. Moderately resistant to root knot nematode. The variety is suitable for cultivation in Kerala, Tamil Nadu, Andhra Pradesh, Telangana Chhattisgarh and Karnataka states.

CARDAMOM VARIETIES

Elettaria cardamomum (L.)Maton

APPANGALA-1 [IISR, KODAGU-SUVASINI]

PPV & FRA Reg.No.: Reg/2010/343

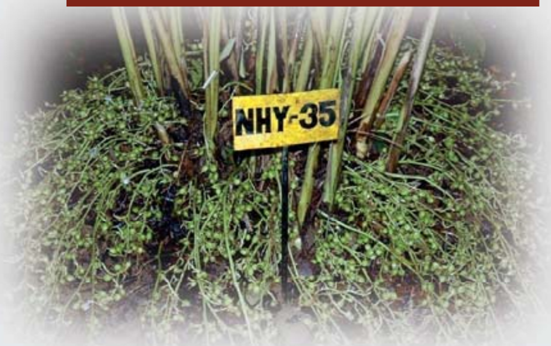
SALIENT FEATURES : Variety has essential oil 8.7%, dry recovery 22%, α- terpenyl acetate 37% and 1,8-Cineole 42%. This has an average yield of 745 kg dry capsules/ha.

MARKET ASPECTS: Suitable for for essential oil extraction industry.

FINANCIAL ASPECTS:

Output capacity	: 745 kg dry capsules/ha	
Expenditure	: @ Rs. 250/kg	Approx. Rs. 2.0 lakhs
Income	: @ Rs. 900/kg	Approx. Rs. 6.5 lakhs
Net Income/ha	: Approx. Rs. 4.5 lakhs	
Cost of planting unit	: Rs.20 per sucker	

IISR APPANGALA-2



SALIENT FEATURES : High essential oil (6.3 %) and α terpinyl acetate (40.32%) content. Resistant to cardamom mosaic virus

MARKET ASPECTS: Suitable for mosaic affected areas

FINANCIAL ASPECTS:

Output capacity	: 1393.12 kg /ha	
Expenditure	: @ Rs. 250/kg	Approx. Rs. 3.0 lakhs
Income	: @ Rs. 900/kg	Approx. Rs. 9.0 lakhs
Net Income/ha	: Approx. Rs. 6 lakhs	
Cost of planting unit	: Rs.20 per sucker	

IISR AVINASH

SALIENT FEATURES: Essential oil 6.7%; dry recovery 20.8%; tolerant to shoot and capsule borer

MARKET ASPECTS: Dark green capsules which fetches premium market prices

FINANCIAL ASPECTS:

Output capacity	: 847 kg dry capsules/ha	
Expenditure	: @ Rs. 250/kg	Approx. Rs. 2.5 lakhs
Income	: @ Rs. 900/kg	Approx. Rs. 7.5 lakhs
Net Income/ha	: Approx. Rs. 5 lakhs	
Cost of planting unit	: Rs.20 per sucker	

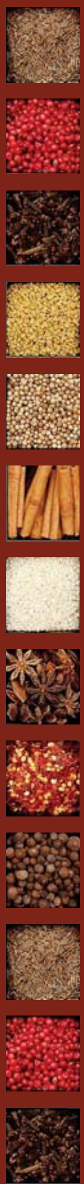
IISR VIJETHA

SALIENT FEATURES: Essential oil 7.9%; dry recovery 22.0%; 77% bold capsules; resistant to katte disease

MARKET ASPECTS: Suitable for mosaic affected areas

FINANCIAL ASPECTS:

Output capacity	: 979 kg dry capsules/ha	
Expenditure	: @ Rs. 250/kg	Approx. Rs. 2.5 lakhs
Income	: @ Rs. 900/kg	Approx. Rs. 8.0 lakhs
Net Income/ha	: Approx. Rs. 5.5 lakhs	
Cost of planting unit	: Rs.20 per sucker	



NUTMEG VARIETIES

Myristica fragrans Houtt.

IISR VISWASHREE

SALIENT FEATURES: Nut recovery 70.0%, mace recovery 35.0% and nut oil 7.14%, mace oil 7.13%, oleoresin in nut 2.48% and mace 13.8% respectively, nut butter 30.9% myristicin, in nut 12.48% and mace 20.03% respectively.

MARKET ASPECTS: High yielding and high quality variety

FINANCIAL ASPECTS:

Mace: Rs.70.000/ha/year, yield @8 years is 480 kg mace/ha @ 800-900 Rs./kgNut: Rs. 312500-625000/ha/year, 3125 kg/ha

First farmers variety under Farmers Participatory Breeding programme

IISR KERALASHREE

SALIENT FEATURES: Nut recovery 70.0%, mace recovery 35.0% and nut oil 5.9%, mace oil 7.5%, oleoresin in nut 9.1% and mace 7.5%, nut butter 24.9% myristicin, in nut 1.6% and mace 9.4% respectively

MARKET ASPECTS: High yielding and high quality variety

FINANCIAL ASPECTS:

Mace: Rs.90.7200/ha/year, yield @10 years is 1512 kg mace/ha @ 600 Rs./kgNut: Rs. 2268000/ha/year, 7560 kg/ha @300Rs/kg

CINNAMON VARIETIES

Cinnamomum verum Presl.

IISR NITHYASHREE

A selection with high shoot regeneration capacity.

- Good quality quills.
- High yield of fresh bark
- High bark oil (2.7%), leaf oil (3%) and bark oleoresin (10%) contents
- Good aroma and taste.

IISR NAVASHREE

A seedling selection from Sri Lankan collection.

- High shoot regeneration capacity.
- High bark oil (2.7%), leaf oil (2.8%) and bark oleoresin (8%) contents

II. Rapid multiplication of black pepper using soil-less nursery mixture in plug-trays

Availability of healthy planting material is a serious problem in black pepper. The present technology is a solution to the non availability of healthy planting material of improved varieties. Partially composted coir pith and vermicompost enriched with *Trichoderma* is used as medium for raising seedlings in plug-trays . Single node black pepper cuttings are planted in the tray and maintained under controlled green house conditions subjected to hardening under shade net green house. The seedlings are ready for field planting within 120 days of nursery rearing. This nursery technique has enabled the production of disease free seedlings with ease for transportation and also enhances successful establishment of vines with vigorous growth. Reduced cost of production (Rs. 6.50 paise/plant.) attracts the low income group farmers to adopt this technology.

Black pepper seedlings in plug tray

III. Single sprout transplanting technology in ginger

A transplanting technique in ginger using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost. The technique involves raising transplants from single sprout seed rhizomes in the pro-tray by using partially composted coir pith and vermicompost enriched with *Trichoderma*. The seedlings can be planted in the field after 30 days. The advantages of this technology are production of healthy planting materials, reduction in seed rhizome quantity and eventually reduced cost on seeds.

Ginger rhizomes and seedlings planted in protray

IV. Vertical column method of planting material production in black pepper

The continuous demand for quality planting material created a novel idea of producing orthotropic branches on vertical column of one feet diameter made of welded wire mesh . Eight to ten cuttings can be planted around each vertical column filled with composted pasteurized cocopeat and vermicompost fortified with bio-control agent *Trichoderma harzianum* in poly house conditions. This system of growing the vine on vertical column can be effectively utilized for the production of top shoots for planting material production which will flower earlier, bush pepper plants and normal single node cuttings.

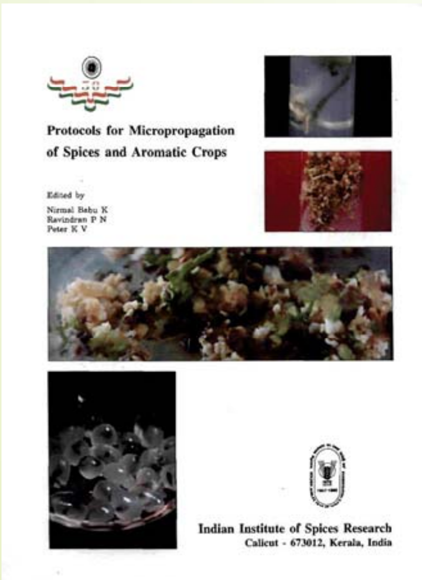
Planting material production by vertical column method

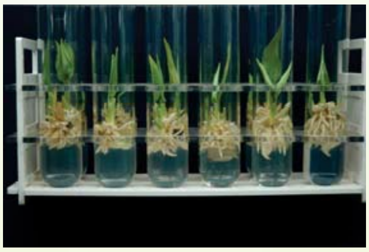
V. Micropropagation protocols for spices

Micropropagation protocols come in handy in multiplying the elite genotypes and production of disease free planting material. These techniques could also be used for multiplication of biomass and in vitro conservation of genetic resources of these crops. The plant regeneration protocols developed can be used for induction and exploitation of somaclonal variation for crop improvement especially in spices with limited variability in germplasm. ICAR-IISR have developed tissue culture protocols for about 31 spices and these technologies are now available for scaling up and commercial production. Technologies for ginger and turmeric have been commercialized to private companies.

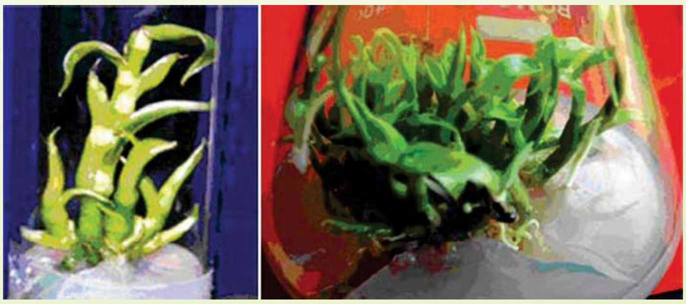
Micropropagation protocols are available for the following spices from ICAR-IISR, Kozhikode

1)Black pepper 2) Indian long pepper 3) Java long pepper 4) Betel vine 5) *Piper colubrinum* 6) *Piper barberi* 7) Cardamom 8) Large cardamom 9) Ginger 10) Mango ginger 11) Turmeric 12) Kasturi turmeric 13) Galangal 14) *Kaempferia rotunda* 15) Vanilla 16) Cinnamon 17) Camphor 18) Chinese cassia 19) Thyme 20) Peppermint 21) Spearmint 22) Marjoram 23) Oregano 24) Sage 25) Lavender 26) Sacred basil 27) Parsley 28) Celery 29) Anise 30) Dill 31) Fennel




Ginger


Black Pepper


Vanilla

VI. Designer micronutrient formulation for spices

Studies show that 40-55% of soils are moderately deficient in micronutrients like Zn (Zinc), while 25-30 % is deficient in B (Boron). Deficiency of other micronutrients occurs in 15 % of soils. In order to find a solution to this serious problem, crop/soil specific micronutrient mixtures for foliar application in black pepper, cardamom, ginger and turmeric which guarantees 15 to 25 % increase in yield and quality have been developed and patents have been filed.

An innate advantage of these mixtures is that they can also be used in organic agriculture and therefore are environment friendly. They are guaranteed to enhance both yield and quality of the crop produce. The technology is a low cost one and also farmer friendly.

So far ICAR-IISR has issued 19 licenses to eight private companies from different parts of the country (Table-2). ICAR-IISR has also assisted the companies through branding of the product, market survey, sensitization and awareness programmes and product launch.

Crop specific micronutrient mixtures of incubatees

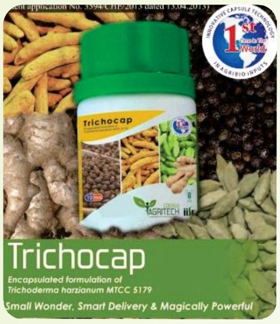
A pilot production plant has been set up at IISR to facilitate production of micronutrients by incubatees.

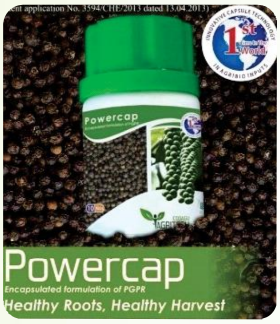
Incubatees engaged in production of micronutrient mixtures at the Pilot facility

VII. A novel method of storing and delivering beneficial microbes through Biocapsules

A novel invention using biocapsule, an easy, reliable technology for storing and delivering beneficial microorganisms by encapsulating in a hard gelatin capsule. The capsule formulation is such that it can be used by suspending in water and used as a soil drench or through drip irrigation. This technology reduces the handling, transportation and storage cost and a patent has been filed (Patent Application No.3594/CHE/2013 dated 13.08.2013) by ICAR-IISR, Kozhikode. Other advantages include enhanced shelf life, no harmful by products, less requirement of inorganic and inert material, storage at normal temperature. One capsule of beneficial microorganism is equivalent to one kilogram talc or one liter of liquid formulation.

ICAR-IISR has signed a non-exclusive agreement for commercial production with M/s Codagu Agritech, Kushal Nagar, Karnataka, and M/s SRT Agro Science Pvt Ltd., Chattisgarh has recently availed the technology and extended to all crops including spices.





Product images of a) Codagu Agritech (Trichocap and Powercap) and b) SRT Agro Sciences Pvt Ltd

Commercial vials of biocapsules from Codagu Agritech, Karnataka and SRT Agro Science Pvt Ltd. Chhattisgarh.

S.No	Trade Name	Crops applicable
M/s SRT Agro Science Pvt Ltd. Chhattisgarh.		
1.	Aceto Caps	Sugar cane, sweet potato, sweet sorghum
2.	Azoto Caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
3.	Rhizo Caps	Leguminous crops
4.	Azoss Caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
5.	Potash Grow Caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
6.	Zinc grow Caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
7.	NPK grow caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
8.	PSB plus Caps	All crops (vegetables, fruits, cereals, trees, ornamentals, beverage crops)
M/s Codagu Agritech, Karnataka		
1.	Tricho cap	Spices, banana, pomegranate
2.	Power cap	Black pepper

VIII. A seed coating composition and a process for its preparation

Seed coating technology is a novel process of coating beneficial microorganisms on seeds. The components consist of live microorganisms, inert material and a binding agent (patent application no. 4465/CHE/2013, Filed On 01.08.2013). The process is done at a particular temperature which is congenial for the organisms to survive and the coated seeds can be stored at the room temperature. Coated seeds exhibited longer shelf life and germination upto 1 year of storage in seed spices. Realizing the wide applicability of this technology, SRT Agro Science Pvt Ltd, our existing licensee for Biocapsule technology has availed the non-exclusive license for commercial production and manufacture of coated seeds of vegetables, grains, fruits and other seeds of commercial importance.

Seed coating in seed spices

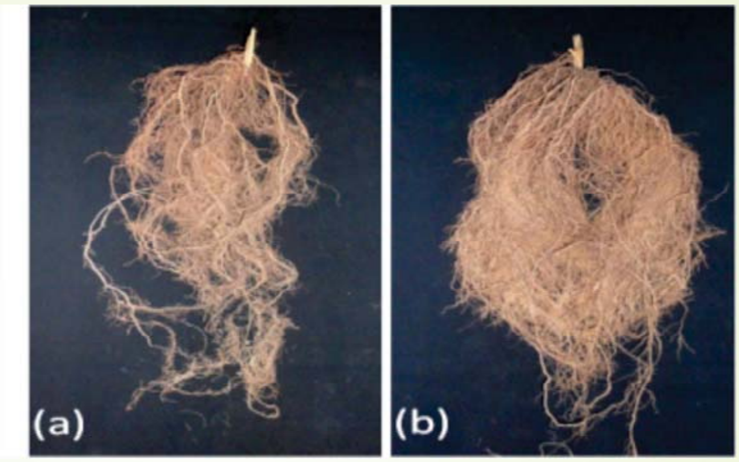
Biocoated Seeds from SRT Agro Science Pvt Ltd. Chhattisgarh.

IX. Microbial consortium for growth promotion in black pepper

The consortium is a combination of three microorganisms namely *Micrococcus luteus*, *Enterobacter aerogenes* and *Micrococcus sp.* It is ecologically safe, increases growth and yield and enhances nutrient mobilization and efficiency in black pepper . It can be applied both in black pepper nurseries and under field condition as soil drench. ICAR-IISR has granted non-exclusive license to M/s Codagu Agritech, Kushal Nagar, Karnataka for commercial production in the encapsulated form.

Formulation of Microbial consortium

Effect of consortium treatment on root growth of black pepper



(a) untreated and (b) treated

X. PGPR Talc formulation for ginger

The talc formulation technology based on a plant growth promoting rhizobacteria (PGPR), *Bacillus amyloliquefaciens* which is specific for ginger This formulation can be applied both as rhizome treatment and soil drench PGPR talc formulation . The major advantages observed are enhanced nutrient mobilization and nutrient use efficiency, increased growth, yield and assured crop protection against soft rot disease. It may be extended to other crops and bioagents too.

PGPR talc formulation for ginger

PGPR treated and untreated ginger in field

XI. *Trichoderma harzianum*, a biocontrol agent against *Phytophthora*

The production of black pepper is hampered by *Phytophthora* foot rot caused by *Phytophthora spp.* not only in India but also in other black pepper growing countries. The talc formulation based on *Trichoderma harzianum* can be used successfully to manage *Phytophthora.* It can be used in Integrated Pest Management as well as under organic farming system in crops like black pepper, ginger, cardamom and turmeric. *T. harzianum* MTCC 5179 is certified as 'biosafe' by INTERNATIONAL INSTITUTE OF BIOTECHNOLOGY and TOXICOLOGY (IIBAT) as per Central Insecticides Board and Registration committee guidelines. There is a great demand for the product and IISR has already issued three licenses for commercial production. District Agricultural Farm (DAF), Thaliparamba, Kannur and M/s Agrilife Biotech, Peroor, Kottayam are our authorized licensees for talc formulation. Another licensee M/s Codagu Agritech is marketing *Trichoderma* as biocapsules.

ADVANTAGES

- It can be used successfully to manage *Phytophthora*
- It ensures socio economic and environmental sustainability
- Its compatible with most of the chemical at prescribed dosage and reduces the cost per ton of output by 78.3% and a saving of 12% per hectare with the cost benefit ratio of 1:3
- It increases productivity by 15-20%.

Bioformulation of *T.harzianum* of our licensee DAF, Thaliparamba & Agrilife Biotech

XII. *Pochonia chlamydosporia*, a biocontrol agent against nematodes

Plant parasitic nematodes, especially root knot nematodes (*Meloidogyne* spp.), are widely prevalent in black pepper gardens of South India and cause significant damage to the plants. Currently they are managed through application of chemical nematicides. Biological control of root knot nematodes, therefore, is highly relevant in this context. *Pochonia chlamydosporia* MTCC 5412, a known fungal nematode biocontrol agent, is a facultative nematode parasite. It proliferates in the rhizosphere, colonizes the egg masses of root knot nematodes, parasitizes their eggs and sedentary females. The fungus attacks all stages of nematode eggs, the immature eggs being more susceptible. As there is an upcoming demand for *Pochonia* in the event of ban on many popular nematicides, ICAR-IISR has recently issued a non-exclusive license for *Pochonia* to M/s Codagu Agritech, Kushal Nagar, Karnataka for commercial production of this biocontrol agent in talc form. In addition to the talc formulation, ICAR-IISR has also developed, liquid formulation technology, which contains chlamydospores in liquid culture with added advantage of increased shelf life. The provisional patent application is deposited with patent office for this invention (TEMP/E-1/36068/2017- CHE) and the technology is yet to be commercialised.

Bioformulation based on *Pochonia chlamydosporia* manufactured & marketed by Codagu Agritech

XIII. *Bacillus licheniformis* , a bioagent for integrated management of bacterial wilt in ginger

A technology for eco-friendly management of Bacterial wilt in Ginger, caused by *Ralstonia pseudosolanacearum* race 4 biovar 3 , a major threat to ginger cultivation in India and word over, has been developed at ICAR-IISR Kozhikode using bacteria. The bacteria was isolated from the apoplastic fluid of ginger and identified as *Bacillus licheniformis* (strain GAP 107). A field application technology has also been developed with this bacteria, which include soil solarization for 45-55 days followed by seed priming and soil applications of *B. licheniformis* (1 x 10^8cfu/g) @ 5 lit/bed at the time of planting and at 30, 45 60 and 90 days. The bacteria possesses plant growth promoting traits besides biocontrol potential.The bacteria showed traits such as siderophore production, production of acetoin, ammonia and indole-3-acetic acid and also enzymes such as amylase, protease and cellulase. The use of this technology is eco-friendly and very effective in combating bacterial wilt pathogen and can be an asset to organic cultivation .

B. licheniformis colonies

Ginger Field at Wayanad Treated with *B. licheniformis*

XIV *Lecanicillium psalliotae* for biological control of cardamom thrips

Control of pests and diseases in cardamom rely heavily on chemical insecticides and farmers adopt more than the recommended sprays for thrips control, leading to environmental and pesticide residue issues making cardamom one of the highest pesticide consuming rain-fed crop. A technology for eco-friendly management of cardamom thrips (*Sciothrips cardamomi*), a serious and persistent insect pest of cardamom has been developed at ICAR-IISR by utilizing a naturally occurring entomopathogenic fungus isolated from cardamom thrips and identified as *Lecanicillium psalliotae*. The fungus infects adults and juvenile stages like larvae and pupae of cardamom thrips, when they come in contact with spores and mycelia of the fungus thus acting as a contact biopesticide. A field application technology has been developed, which involves 3-4 applications of *L. psalliotae* (1 x 10^8cfu/g) in the basins of plants for effective control of cardamom thrips. The treatment with the entomopathogenic fungus was onpar with synthetic chemical insecticides in controlling the pest. The fungus also possesses plant growth promoting traits such as production of indole-3-acetic acid and ammonia, solubilization of inorganic phosphate and zinc, production of siderophores and cell wall-degrading enzymes like amylase, cellulase and protease. Application of the fungus to cardamom seedlings increases shoot and root length and biomass, number of secondary roots and leaves and total leaf chlorophyll content of the plants. This technology is very safe to non-target organisms and environment and can be used in organic production of cardamom. An application for provisional patent for a granular formulation of this biocontrol agent has been deposited (201741044872 dated 13.12.2017) and the technology is being commercialized.

Mycelial growth of *L. psalliotae* on cardamom thrips

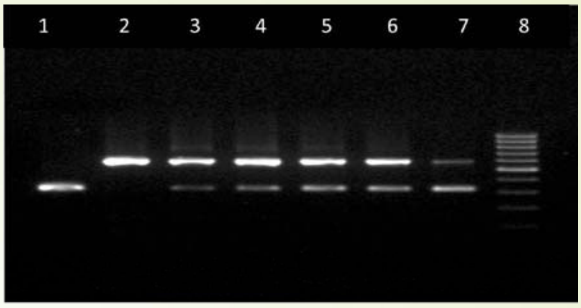
Comparison of growth of cardamom seedlings in untreated control and plants applied with *Lecanicillium psalliotae*

XV. Adulterant detection in spices using DNA barcoding

Adulteration is common in all spices. Utilization of DNA barcoding is the only way to detect biological adulterants in traded spice commodities. DNA barcoding is a technique based on the sequence variation in short nucleotide regions called barcodes between species. Barcoding finds application in authentication of agricultural commodities including spices. We have utilized the barcoding approach in authentication of traded spices like black pepper, turmeric, cinnamon bark and nutmeg mace.

We can detect

- Chilli adulteration in black pepper
- Adulteration of spice powders with starchy materials like rice, wheat, cassava etc
- Adulteration of cinnamon bark with cassia
- Adulteration of a related species M. malabarica in traded nutmeg mace



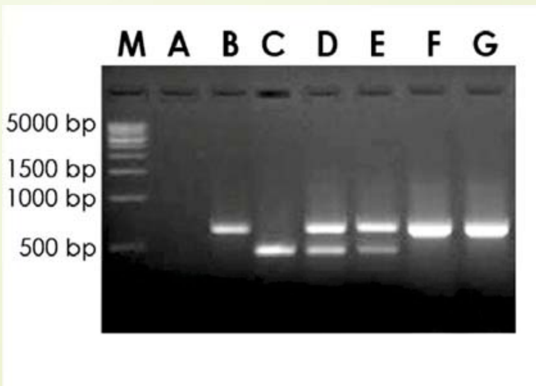
PCR based detection of adulteration of chilli in black pepper

XVI. Diagnostics for viruses infecting black pepper and cardamom

This method uses a single tube multiplex reverse transcription (RT) coupled (Polymerase Chain Reaction) PCR Assay (mRT-PCR) for simultaneous detection of two viruses (cucumber mosaic virus and piper yellow mottle virus infecting black pepper. RT-PCR is used to qualitatively detect gene expression through creation of complementary DNA (cDNA) transcripts from RNA, qPCR is used to quantitatively measure the amplification of DNA using fluorescent dyes.

Black pepper is infected by two viruses (Cucumber mosaic virus and Piper yellow mottle virus) where as cardamom is infected by two viruses (Cardamom mosaic virus and Banana bract mosaic virus) which are systemic in nature. Once infected, viruses cannot be eradicated by any means including chemicals. Hence it is advisable to use certified virus-free material for planting. The technology can be used for certification of mother plants/planting materials of black pepper for freedom from viruses.

Virus infected black pepper



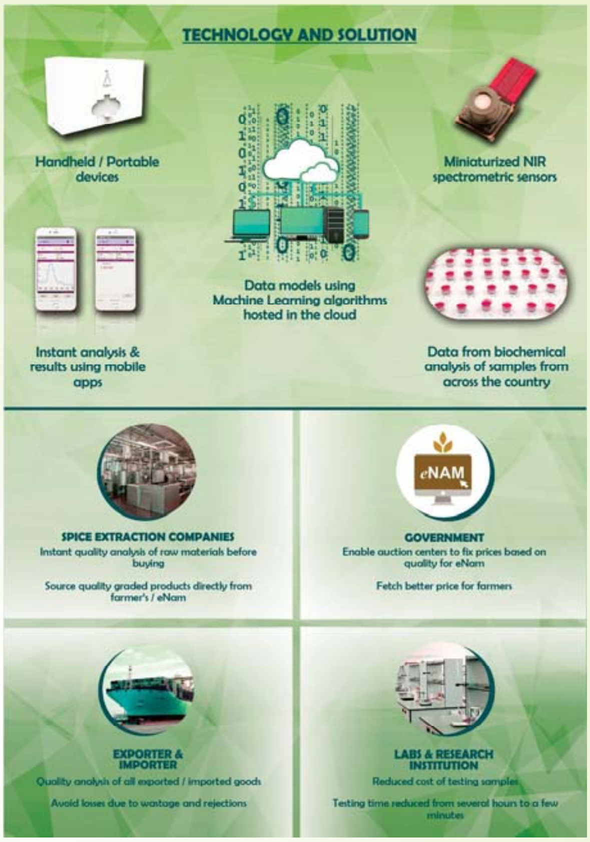
PCR result

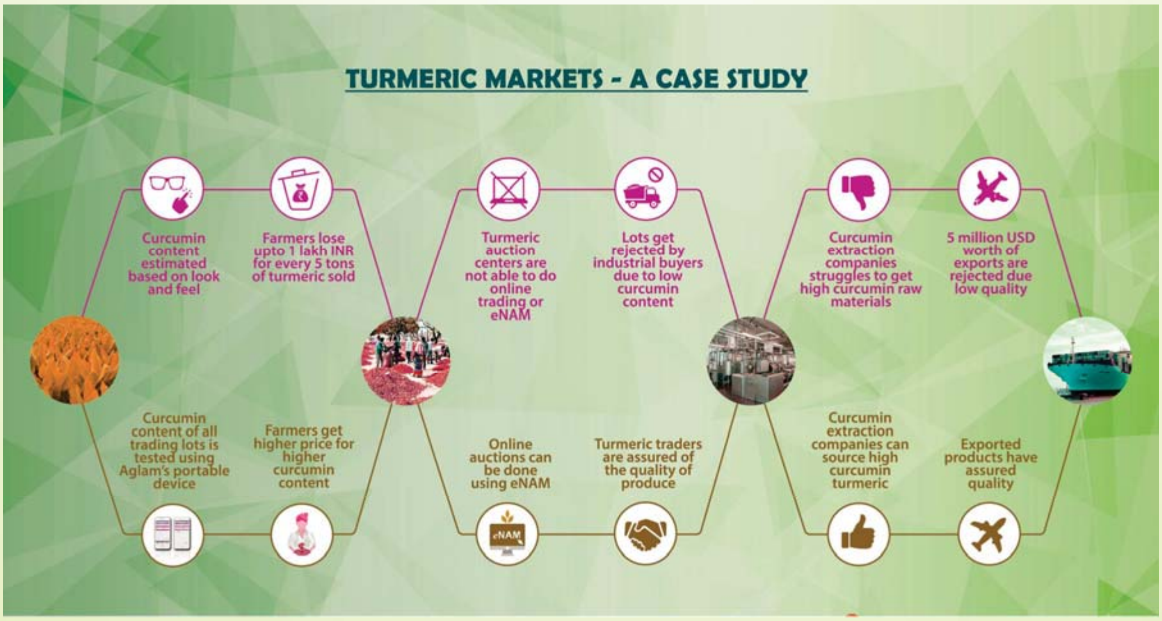
Home

XVII. Mobile App-based instant analysis of turmeric quality using hand held spectrometers.

Developing a system framework that enables reliable, fast and cost-effective spectroscopicanalysis of curcumin / oleoresin/moisture/starch content in turmeric using handheld spectrometers in combination with mobile/desktop/ web applications.

Mobile App for instant detection of curcumin under trial at the turmeric Mandi in Erode by Aglam Tech Pvt. Ltd, Kerala





PROCESS & DEVICES

SPICE PROCESSING FACILITY

The Spice Processing Facility was established at ICAR-IISR, Experimental Farm, Peruvannamuzhi, Kozhikode during 2013-14 with the financial support from National Agricultural Innovation Project (NAIP). The main objective of this facility is capacity building and entrepreneurship development in spice processing. The facility is equipped with state of art equipments for primary as well as secondary processing of spices, composed of units for cleaning and grading of black pepper, spice/curry powder production and white pepper production. The facility has also obtained the “Manufacturing license” from Food Safety and Standards Authority of India (FSSAI) and is currently handholding four clients for commercial production and marketing of spice/curry powder.

Black pepper cleaning and grading unit

Curry powder production unit

White pepper production unit

Products of our spice processing clients

New Business Initiatives and Startups

Dr. Sheeba Veluthoor, *CoreValleys Herbal Technologies Pvt. Ltd., Kozhikode for developing innovative and natural spice based cosmetics and food products under the brand name "Nach" with a mission to promote health and wellness with incubation support from ICAR-IISR*

Mr. Aloak Menon- *For manufacturing and marketing innovative and unique spice blends accruing indigenous spices from farmers under the mentorship of ICAR-IISR*

Mrs. M. Maya- *Will be developing indigenous and traditional food items and herbal products under the brand name 'Good Mom's" with incubation support from ICAR-IISR*

Mr. Nandagopal Stephen: *Will be doing direct marketing of "Biocapsules" for agriculturally important microbes through Krishi Bhavans with incubation support from ICAR-IISR*

Table 1 : Licensees of plant varieties

Name	Variety
Mr. Abdul Nabeel P. Pattorakkal, Natura Meppayur P.O. Kerala	IISR Prathibha
Mr. Jigar Dipakbhai Patel 3 Charotar Patel Society, Ahmedabad-380008, Gujarat	IISR Prathibha IISR Rejatha IISR Alleppey Supreme
The Director Centre for Overall Development (COD), Thamarassery, Kozhikode – 673 573, Kerala	IISR Varada IISR Alleppey Supreme
Mr. S. Shashikant Patil Raikode Mandal, Medak District, Telangana-502257	IISR Mahima
Mr. Kasarenibabu Nature Agro Producers Guntur District, Andhra Pradesh, 522502	IISR Pragati
Mr. Pidikiti Chandrasekhar Azad, Guntur Dist , Andhra Pradesh- 522303	IISR Pragati
Mr. Prakash Vasant Kane 87/3, Chandrama, Dr. Ketkar road, Erandwane Near Kamala Nehru Park, Pune- 411004	Turmeric IISR Prathibha
Mr. Rajeev Chandnahu Nature Resorts & Organic Farms India Pvt Ltd, Behind Ram Mandir, Beside VV Apartment, Shanti Nagar, Raipur- 492001	Turmeric-IISR Prathibha IISR Pragati
Dr. Goutham Palani Genewin Biotech, Hosur, Tamil Nadu	Ginger -IISR Varada
Ram Prasad Reddy Medak, Telangana	Turmeric -IISR Pragati
Mr. Tom C. Antony Cheripurathu Nursery Kottayam, Kerala-686585	IISR Viswashree
Mr. Mathew Sebastian Thazhathel, Melattur Post- 679 326 Malappuram, Kerala	IISR Keralashree
Mr. Venugopal S. J. Shri Navaneetha Nursery, Puttur, Karnataka-574 202	IISR Keralashree
Mr. Martin Manual, Unnikulam, Kozhikode,Kerala -673 574	IISR Thevam
Mr. Girish N. Hegde, Sahyadri Nursery & Farm, Shimoga,Karnataka-577401.	IISR Thevam IISR Girimunda
Mrs Thabeera K M/s Natura Nursery & Agro Products Meppayoor Po, Malappuram, Kozhikode	Black Pepper-IISR Thevam
Mukesh Chouradia Unique Associates, C2/301, 3rd Floor, Aishwary Chamber, Telibnadha,	Turmeric IISR Prathibha, IISR Pragati
Mrs. Sai Gole LeanCrop Technology Solutions Pvt. Ltd. 88, Vinay Nagar, Kesarbag road, Indore, Madhya Pradesh- 452009	Turmeric -IISR Pragati

Home

Table 2 : List of Licensees

Spice Processing Unit

SUBICSHA
Coconut Producer Company Ltd.
Naduvannur Via, Kozhikode , Kerala

M/s Mannil Spices
Perambra,Kozhikode

M/s Maaloos Pure Food Mix,
Merikunnu, Calicut-673012,
Kerala, INDIA

M/s Innofarm Agricultural Producer company
Koodaranhi.P.O., Kozhikode, Kerala - 673 604

The Central Arecanut & Cocoa Marketing & Processing Co-operative Ltd.
Mangalore, Karnataka-575001

Trichoderma harzianum

Farm Superintendent
District Agricultural Farm
Taliparamba, Kannur, Kerala-670142

M/s. Agri Life Biotech,
Peroor, Kottayam, Kerala- 686637

Codagu Agritech
Kushalnagar, Karnataka - 571234

Biocapsule technology

Codagu Agritech
Kushalnagar, Karnataka - 571234

SRT Agro Sciences Pvt Ltd,
Village Funda, Patan District, Durg,, Chattisgarh

PGPR for black pepper

Codagu Agritech
Kushalnagar – 571234, Karnataka

Micronutrient formulation

M/s Natura Agro & Nursery Products,
Meppayur P.O., Kerala-673524

M/s Shrey Agritech
Hubli, Karnataka-580030

M/s Hi-7Agro Bio Solutions,
Hessaraghatta,Bengaluru
Karnataka--560088

RLCO INNOVATIVE AGRI PRIVATE LIMITED
27/498, Parayancheri, Kuthiravattom (PO),
Kozhikode, 673016

M/s Linga Chemicals
Madurai
Tamilnadu-625001

M/s Rainbow Agri Life India Pvt. Ltd
Kadapa, Andhra Pradesh-516002

M/s Raja Enterprises
Salem
Tamilnadu

M/s. A & N Traders
Thodupuzha
Idukki (Dt), Kerala-685584

Seed Coating

SRT Agro Sciences Pvt Ltd,
Village Funda, Patan District, Durg,
Chattisgarh

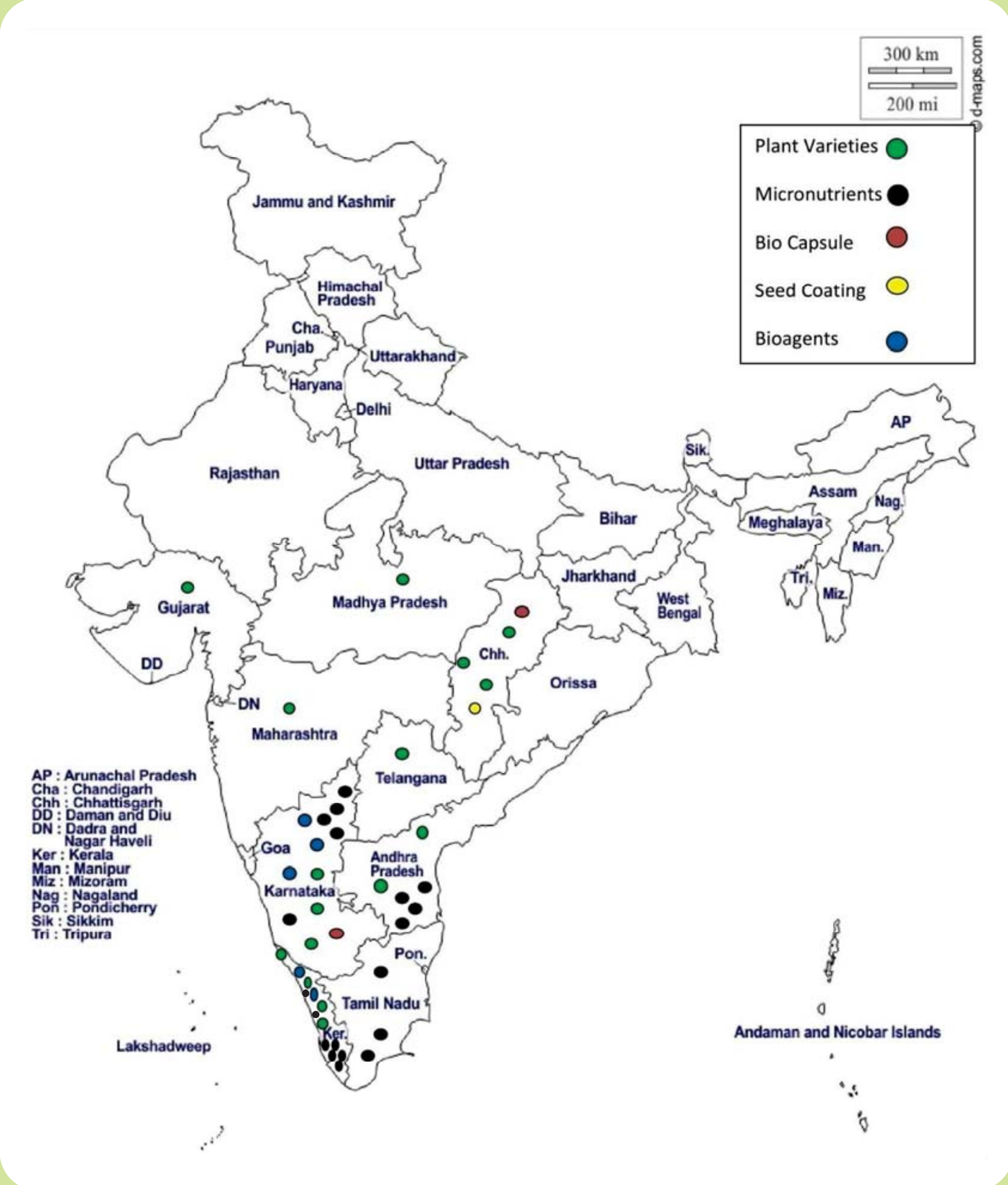
Pochonia chlamydosporia talc

Codagu Agritech
Kushalnagar, Karnataka - 571234

Our Licensees / Collaborators

Total technologies commercialised: 55

States covered: Kerala, Tamil Nadu, Maharashtra, Telengana, Chhattisgarh, Gujarat, Karnataka, Madhya Pradesh



Home

Published by
Director
ICAR - Indian Institute of Spices Research

Edited By
Dr. Sheeja T.E
Dr.Prameela T.P
Ms.Lakshmi R Menon
Mr. Abdul Razak

For further details contact:

Institute Technology Management-Business Planning and Development Unit (ITM-BPDU)
ICAR-Indian Institute of Spices Research,
Marikunnu PO, Kozhikode, Kerala-673012
Ph: 0495-2731410
Email: itmu@spices.res.in, bpd.iisr@gmail.com
Web: www.spices.res.in