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ON
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SYMSAC-VIII

Towards 2050 - Strategies for Sustainable Spices Production

16-18 December 2015

Tamil Nadu Agricultural University
Coimbatore, Tamil Nadu

Souvenir & Abstracts

Organized by

Indian Society for Spices
Kozhikode
Tamil Nadu Agricultural University
Coimbatore

In Collaboration with

Indian Council of Agricultural Research
New Delhi
ICAR-Indian Institute of Spices Research
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National Horticulture Board, Gurgaon
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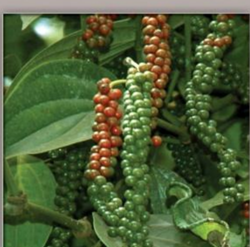
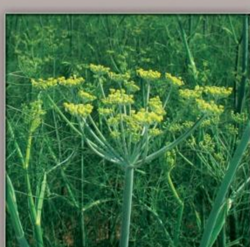

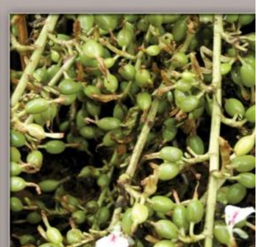

NATIONAL SYMPOSIUM ON SPICES AND AROMATIC CROPS (SYMSAC –VIII)

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Compiled and Edited by

Krishnamurthy K S, Biju C N, Jayashree E, Prasath D, Dinesh R, Suresh J&NirmalBabu K

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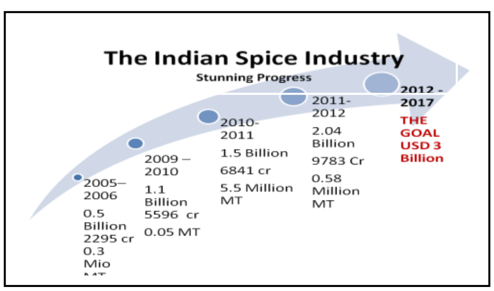
Spices – Way forward

N K Krishna Kumar

Deputy Director General (Horticultural Sciences)
Indian Council of Agricultutural Research, New Delhi
ddghort@gmail.com

Civilizations of Asia were involved in spice production, utilization and trade since ancient times. Spices are high value and low volume commodities of commerce in the world market. Globally, the fast growing food industry depends largely on spices for imparting taste and flavour. Health conscious consumers in developed countries prefer natural colours and flavours of plant origin to cheap synthetic products. Thus, spices form the basic building blocks of flavour in food preparations in addition to their use as functional foods, nutraceuticals and sources of several high value phytochemicals.

Spices are integral to human life, especially in Indian society; in tradition, food, aroma, health and economy and every positive development in spices improves the quality of life world over. India is the largest producer of spices with an annual production of 5.8 million MT during 2012-13 from an area of 3.1 million hectares. 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 and mint is a herbal spice of importance. Garcinia, black cumin, ajowain, saffron, mint, oregano, lavender, star anise are considered as future crops among the 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 the other spices. After a domestic consumption of more than 70% of the spices produced, India still remains as the largest exporter of spices in all its forms; raw, ground and processed and as active ingredient isolates. India contributes 48% of the total world trade in quantity and 43% of the value. During 2012-13, 19000 tonnes of curry powder blends valued at Rs. 298.4 crores has been exported. Export of spice oils and oleoresins has recorded an all time high of 8670 tonnes valued at Rs. 1312.8 crores in 2012-13. The estimated growth rate for spice demand in the world is around 3.19%. The spice industry in India and trade has shown stunning progress over the last 5 years with 120% increase in revenue which is expected to touch $ 3 billion by 2017. East Asia is the major market for spices, followed by America and the European Union and the world spice trade is expected to touch $ 17 billion by 2020.



Indian spices flavour foods all over the world and use of spices is ever increasing in food, medicine and pharmaceutical industry. The consumption of spices is growing in the country with increase in purchasing power. It is envisaged that, everyone in India would be consuming one spice or the other with a higher per capita consumption. It is estimated that, we may have a population of about 1.69

billion during 2050 and approximately the per capita consumption of black pepper, cardamom, turmeric and ginger is expected to be about 148 g, 54 g, 1.6 kg and 1.2 kg, respectively. Adding to this India is expected to have the second largest urban population (0.9 billion) in the world by 2050.

Table 1. Production and productivity of major spices (2012-13)

Spice	World			India			Productivity demand by 2050 (kg ha^{-1})
	Area (m ha)	Production (m t)	Productivity (kg ha^{-1})	Area (m ha)	Production (m t)	Productivity (kg ha^{-1})	
Black Pepper	460.7	279.9	607.5	124.6	52.6	422	940
Cardamom	161.4	45.0	278.7	92.4	18.4	199	990
Turmeric	195.1	992.9	5089.2	194.2	971.1	5000	9350
Ginger	310.4	1683.0	5421.5	136.2	682.6	5011	10030

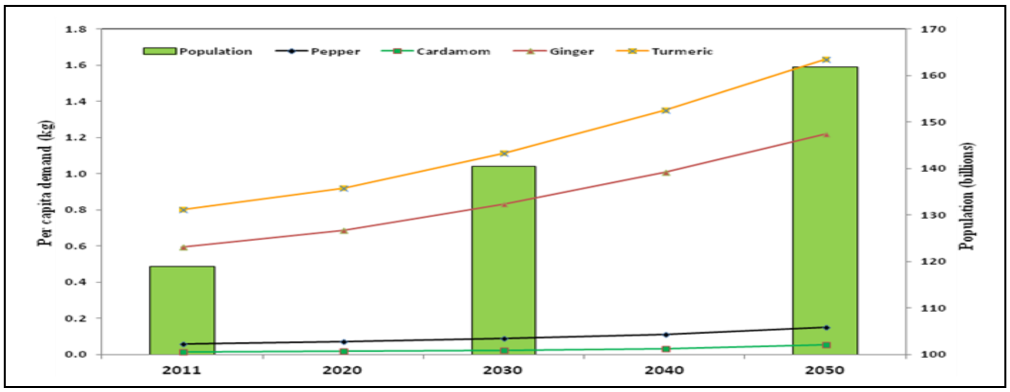


Fig. 1. Estimated per capita demand for major spices in 2050

Spices as functional foods and nutraceuticals

In addition to their use as medicine, additives for flavouring food and preserving foods as well as beverages, spices also have nutritional, antioxidant, antimicrobial and insect repellent properties. They are rich source of proteins, vitamins (A, C, B, E) and minerals such as calcium, phosphorus, sodium and iron. The beneficial properties of spices are attributed to the presence of phytochemicals. The major phytochemical classes associated with spices include a diverse array of compounds such as terpenes and terpene derivatives. Both *in vitro* and *in vivo* studies have suggested that, dietary spices and herbs maintain human health by their antioxidative, chemo-preventive, anti-mutagenic, anti-inflammatory and immune modulatory effects.

Challenges

Over the years, India's share in world spice market has not appreciated much and it's monopoly as a supplier of spices is threatened by countries like China, Brazil, Vietnam, Pakistan, Egypt, Turkey and other African and Caribbean countries. India also faces shortage of exportable surplus because of increasing domestic demand. Sharp fluctuations in the quantum and value of exports and in the unit value realization have characterized the spice trade in recent years.

Table 2. Global competitors for India in production and export of major spices

Spice	Competing country
Black pepper	Indonesia, Brazil, Malaysia, Thailand, Sri Lanka, Vietnam, China, Madagascar, Mexico
Cardamom	Guatemala, El Salvador, Indonesia, Malaysia, Papua New Guinea, Sri Lanka
Ginger	China, Thailand, Japan, Bangladesh, South Korea, Malaysia, Fiji, Philippines, Jamaica, Nigeria, Sierra Leone
Turmeric	China, Pakistan, Bangladesh, Thailand, Peru, Jamaica, Spain
Clove	Brazil, Indonesia, Madagascar, Malaysia, Papua New Guinea, Sri Lanka
Nutmeg and mace	Grenada, Guatemala, Mexico, Nicaragua, Sri Lanka
Cassia	China, Indonesia, Madagascar, Malaysia, Vietnam
Cinnamon	Sri Lanka, Madagascar, Papua New Guinea, Seychelles
Coriander	Morocco, Russia, East European countries, France, Central America, Mexico, USA
Cumin	Syria , Iran, Turkey
Fennel	China, Turkey, Egypt
Fenugreek	Morocco, Turkey, Japan, USA
Ajowain	Iran, Egypt, Afghanistan
Mint	USA, China

Amid the stunning progress and ambitious vision, there are challenges that threaten spice marketing and industry. High cost of cultivation, problems in supply chain, rising demand $^{v}/_{s}$ raw material storage, reducing productivity, market instability, reducing quality and active ingredient content, increasing incidence of contaminants (aflatoxin, pesticides, illegal dyes, microbials *etc*), stringent food safety standards,overwhelming regulations and ecological sustainability has affected spice industry and trade. This is further complicated by uncompetitive production costs in comparison to other countries such as Vietnam and China.

Maintaining hygiene and cleanliness at different points in the supply chain, right from the supply of agricultural inputs to consumption through mechanization is important. Greater efforts focused on increasing production and productivity levels through GAP in spices are needed to make them more sustainable and safe.In order to produce a final product that is acceptable as 'safe food', one need to be able to control all the elements in the supply chain with the support of all the stakeholders. This is further supplemented by harmonization of global standards on bio-safety, ensuring sustainability of supplies and to bridge the demand and supply imbalances without adversely affecting the environment involving producers, traders, industry and consumers and adjusting to emerging market trends. In view of this, greater efforts are focused on sustainable increase in production through high production technologies integrating improved varieties, disease, pest and nutrient management, for which cropping system approach, organic farming and GAPs need to be evolved. Many facets of spice cultivation, harvesting, storage and processing can be mechanized. Improving and harmonization of standards for production, post harvest technology, processing, marketing and bio-safety issues of spices are of paramount importance to the spice industry. The intrinsic quality as well as flavour and other components of spices are dependent of the agro-climatic conditions in which they are grown. Hence, development of Geographical Indication (GI) for spices is important for obtaining the best spices and for better pricing. Establishment of spice parks and enabling infrastructure to develop end-to-end capability is another positive development. Upgradation of technologies across the entire supply chain is a key driver for sustainable growth.

Product development, diversification and value addition need a greater thrust and innovation to achieve greater commercial importance. In a world with several lifestyle diseases, spices with its chemo-preventive, antioxidant, anti-inflammatory, antimicrobial and insecticidal properties, bioenhancer potential are gaining importance as functional foods and are used as dietary supplements. With greater amounts of biomolecules with important health notes, the spices need to be exploited towards problem solving approaches so as to enhance the human health.

The awareness about spices is increasing. The demand for organic spices is growing @20% annually. Spices are finding newer applications in food, cosmetics and pharmaceuticals. Sustainability and food safety are of crucial importance today and need serious deliberation, pro-active action and an active coming-together of all the stakeholders. Global initiatives need to be intensified by bringing together the global spice industry to define and set an implementable pathway to secure a sustainable future for the industry and the agriculture system which supports the industry, while also examining the industry's ecological and social impact. The rise of e-commerce must help in alternate price discovery mechanisms. If we utilize these opportunities the spice industry and marketing is poised for exponential growth.

Imports

The total import of spices in India during 2012-13 is about 1.31 lakh tonnes valued Rs. 2102.3 crores. The import value has increased by 18% as compared to previous years. The major spices imported are ginger, black pepper, poppy seed, clove, star anise and cassia. Out of the total import of black pepper (15800 t), more than 60% is light (immature) pepper for oleoresin extraction and re-export. Fresh ginger is imported mainly from Nepal (30% of import volume) for industrial consumption.

The strengths and weaknesses of Indian spices production and utilization (SWOT)

Strengths

- Strong research and development base
- Vibrant industry and trade
- Wide genetic diversity
- Availability of location specific high production technologies - IPM, IDM and INM
- Over 150 improved varieties

Weaknesses

- Stagnant productivity
- Absence of high degree of resistance to biotic and abiotic stresses
- Lack of quality planting materials of high yielding varieties
- Low adoptability of technologies, mechanization and hygienic practices
- High contaminants
- Unable to meet global safety standards
- Price instability
- Lack of connectivity
- Lack of effective transfer of technology

Opportunities

- The demand and awareness of spices is growing
- Newer applications in food (functional), cosmetics and pharmaceuticals
- Increasing demand in non-traditional areas
- Intercrop in many plantation crops
- Scope for MAS and convergent breeding
- Development of a network of certified nurseries and biocontrol units in PPP mode
- Protected cultivation, urban cultivation and off-season cultivation
- GAPs and contract farming
- New crops
- IPR and farmers varieties – participatory plant breeding
- New products and high value compounds

Threats

- International competition, bio-piracy and patenting
- Sanitary, food safety and bio-safety issues
- Market fluctuations
- Declining labour force, soil fertility and water resources
- Climate change

Expectations

To achieve the targeted production and export in spices in 2050, sustained research, development and industrial initiatives to overcome the constraints becomes pivotal. Increasing the productivity per unit area through spice-based farming systems, development of varieties with high degree of resistance to biotic and abiotic stresses, development of agro-technologies towards low input management, precision farming, developing eco-friendly IPM strategies, post harvest technologies with value addition and exploiting its medicinal properties and popularization of proven technologies through extension network are the major areas. Besides, the new areas on nanotechnology, bioinformatics, carbon (C) and water foot prints and knowledge management would further strengthen the research programmes on climate resilient agriculture. These technological advancements will bring out the surge in productivity of spices and 2-5 fold increase in all major spices, to meet the consumption and export demand. The forecasted spice production by 2050 is expected to be achieved with an annual compound growth rate (ACGR) of about 3%. Awareness programmes for producers to follow hygienic practices and to develop clean spices will help partially but may help in better pricing. The advances made in spice improvement, production, protection, microbial and post-harvest technology must be popularized among all stakeholders through NGOs, SHGs through participatory technology development. In addition to visual and print media, mobile technology can also be used for quick transmission of information and to give alerts.

Harmonization of global standards on bio-safety, ensuring sustainability of supplies and to bridge the demand and supply imbalances without adversely affecting the environment involving producers, traders, industry and consumers and adjusting to emerging market trends are highly imperative for sustainable development. It is centuries old knowledge that spices have many medicinal and nutraceutical properties. Culinary spices can inhibit several food-borne pathogens. In addition to known properties, they are the natural sources of anti-obesity (hydroxy citric acid from garcinia), anti-oxidant (curcumin from turmeric), anti-carcinogenic (turmeric, myristicin andelemicin from nutmeg), anti-ageing (turmeric), anti-Alzheimer's (turmeric), anti-diabetic (fenugreek, cinnamon) and anti-viral (star anise used in Tamiflu vaccine), antimicrobial (terpenoids from many spices) compounds. Piperine from pepper, in addition to its known medicinal properties, was reported to enhance the absorption and efficiency of many drugs and hence, has a great potential in pharmaceutical industry. Cardamom seeds can be a good source of mouth refreshner. Many more bio-molecules of nutraceutical value can be identified and utilized in health care industry. Many bio-informatics tools are available and can be used for drug discovery and warrants priority.

Increase in spice production will also lead to a significant growth in on-farm employment opportunities. The spice industry is expected to create surplus employment potential in production alone as spice crops are labour intensive. Further, there is substantial scope for creating new jobs through value addition in spices. The envisaged increase in share of value added products in the export basket of spices needs strengthening of processing facilities both on-farm and outside. The development of downstream processing, packaging and distribution activities can also generate millions of additional off-farm jobs. Thus, the spice industry will help the country to achieve its goal of more than 10% growth rate in GDP and to sustain the same. Nanotechnology has been identified as an important component in future in maximizing the productivity of agriculture. Though there are many toxicology concerns, this technology has great potential in developing new tools for rapid disease diagnosis and to combat pathogens, enhancing nutrient absorption, developing efficient pesticides, separation, identification and quantification of biological molecules, soil and water management, bio-processing, post-harvest technology, monitoring the identity and quality of agricultural products and precision agriculture. Web-based interactive data bases providing expert systems and instant information on, for example, weekly analysis for spices, future predictions on demand, supply and pricing, directories of products, buyers, sellers, agents and statistics *etc.* are available for traders but more are needed especially for supporting farming community also. Finally governmental involvement is also required in providing incentives to agriculture, industry and trade, to remove trade barriers in the form of unfair regulations simplification of policies and procedures and in export–import trade agreements with emerging markets is an area that requires governmental involvement. If we utilize these opportunities,the spice industry and marketing are poised for exponential growth

Way forward

The mission is to capture India's pre-eminent position as *'spice bowl of the world'* by producing and exporting the best spices and spice products the world can expect. This translates to enhancing the productivity and quality of spices and spice products for meeting growing domestic demand and to be the global leader in spice exports by utilizing scientific, technological and traditional strengths for sustainable production. This can be achieved by obtaining high productivity of clean spices through varietal deployment, plant and soil health, optimal and safe technologies, better storage and processing, product development for food as well as pharma industry, mechanization, better market intelligence and aggressive marketing. The objective is also to have doubled exports. The initiatives under secondary agriculture and development of new products that find way into nutraceuticals and pharmacological applications paves way for value addition. The modern tools of science using several '*omics*' is helping to unravel several metabolic pathways that contribute to the intrinsic quality of spices and the mechanism of host-pathogen interactions. Most technologies needed are either already available or in advanced stage of development. They need to be fine tuned and implemented urgently.

Challenge	Way forward
Declining productivity	• Convergent breeding and ideotype development • Intelligent deployment of location specific disease resistant varieties • High production technologies • High density planting • Genomics and MAS • Elucidating biosynthetic pathways of important secondary metabolites in spices through genomics and metabolomics approaches for bioengineering • Participatory breeding
Planting materials	• Accredited and certified nurseries • Delivery of biological agents and PGPR • Diagnostics • Quarantine during movement of planting materials across the states
Resource limitations	• Conservation agriculture • Water harvesting and intelligent/optimized utilization • Precision farming, soil health management through micro-irrigation, micronutrients and fertigation • Foliar nutrition
Plant protection	• Integrated management of major disease and pests • Bio-risk management • Nano technology
Reduction of area	• Expanding to new non-traditional areas • Cropping systems as intercrop in other plantation crops
Farm labour	• Mechanization of on-farm operations and processing
Stringent global food safety standards	• Developing and implementing GAPs • Organic farming • Contract cultivation • HRD and skill development • Packaging • Maintaining hygiene in all operations
Fluctuating market prices	• Market intelligence • Storage facilities • Off-season cultivation • New markets
PHT and value addition	• Chemo-profiling • New product development • Popularize as functional foods • Fortification • Pharma industry • Participatory technology development
Domestic market needs	• Urban and peri-urban horticulture • Protected cultivation • Vertical farming
Industry needs	• Mapping of GI • Mapping of best spice producing regions • Deploying varieties with high quality

	• Spice parks
Climate change	• Climate resilient varieties • Climate smart cultivation • Disease and pest surveillance
Sustainability	• Optimal technologies • Harvesting solar energy for farm and industry needs • Farmer, industry, trade collaboration and synergy • Equitable profit sharing
TOT	• Aggressing marketing • Knowledge sharing and use of IT • Incubation centres • Periodic interactions
IPR	• Documentation of ITKs • Whole genome, transcriptome, metabolome and sequencing • Bio-prospecting • Isolating, processing and patenting high value compounds (phytochemicals)

Crop-wise priorities

Black pepper

- Development of *Phytophthora*, nematode, pollu resistant and low input efficient varieties with high quality parameters
- Popularizing bush pepper technology in urban horticulture/home gardens to meet part of domestic demand and availability of safe and fresh pepper
- Popularization and use of piperine as bio-enhancer for higher returns

Cardamom

- Development of thrips resistant genotypes
- Development and popularization of biocontrol agents for control of shoot and capsule borer
- Identification and deployment of varieties with synchronous flowering to reduce number of harvests
- Biannual replanting for increased production on short-term basis

Ginger

- Development of varieties resistant to rhizome rot/bacterial wilt (*Pythium* and *Ralstonia*) and varieties suitable for vegetable types and high quality
- Isolation and popularization of high value products and phytochemicals
- Protected soil-less cultivation
- Popularization of mechanization in farm operations and processing

Turmeric

- Development of dry rot (*Pythium*) and leaf disease (*Taphrina*) resistant turmeric varieties with high curcumin preferably with golden yellow colour
- Popularization of mechanization in farm operations and processing

- Popularization and use of turmeric as a major ingredient in formulations/drugs for cancer and Alzheimer's treatment

Nutmeg

- Development of bisexual and off-season types for increased yield and reduced aflatoxin
- Canopy architecture and development of early flowering, dwarf types for ultra high density planting and urban horticulture
- Developing low myristicin types for food industry
- Isolating and utilization of myristicin and elemicin derivatives for cancer treatment

Clove

- Multiplication and deployment of bold 'King' and 'Madagascar' types for increased market preference
- Popularization of dwarf types in homestead and urban gardens

Cinnamon

- Development of low coumarin types with high regeneration ability
- High production and harvesting technologies to harvest large number of cinnamon pencils (quills) and extra time earning opportunities for women at home
- Development and popularization of cinnamon products for diabetes control

Garcinia

- Identification and deployment of nutritionally rich and high HCA types and establishing commercial plantations
- Development and popularization of garcinia juice/drinks as health drinks for obesity control

Tamarind

- High density planting of dwarf high yielding types in waste lands for increasing production and dry land agriculture
- Developing sweet types for confectionary as well as spice purpose

Coriander

- Deployment of stem gall and mildew resistant varieties
- Development and deployment of dual purpose, multi-cut varieties for initial leaf and later grain yield
- Protected cultivation of leafy coriander in urban roof tops and households for quick returns (one crop in 30 days)

Cumin

- Develop wilt and blight resistant varieties and aggressive implementation of GAPs to avoid mancozeb contamination
- Strict implementation of GAPs through contract cultivation

- Development of technologies to avoid losses caused due to frost even in partially protected cultivation
- Growing cumin in non-traditional areas

Fennel

- Development of varieties with synchronous flowering (whole umbel) and maturity of seeds/grains
- Use of micro-irrigation and transplanting for better yields
- Harvesting at different stages for value addition and different uses (*e.g*. early harvesting for sweet fennel for mouth refreshners)

Fenugreek

- Developing dual purpose high value types for use as functional foods
- Popularization of determinate types for mechanized seed harvesting

Ajowain & Black cumin

- Development of high yielding varieties

Mint

- Development of high menthol yielding varieties

Saffron

- Protected cultivation throughout the year using controlled temperature regimes and aeroponics

Other new initiatives

- Deployment of high yielding, water use efficient climate resilient genotypes and technologies
- Accreditation of nurseries
- Multiplication of only released varieties and strict quarantine during movement of planting materials across the states/regions to avoid disease spread
- Micro-irrigation/fertigation for precision and optimal farming
- Bringing automation and IT into precision farming
- Technology use of recycled waste water as well as urban waste coupled with bio-inoculants for organic cultivation
- Use of solar energy for majority of farms as well as processing
- Optimal cultivation of spices as intercrops in existing plantation (coconut, arecanut, coffee, tea *etc.*) and fruit crops (mango, sapota, guava, aonla *etc.*)
- Refining plant architecture (small bushy plant types) for making perennial spices suitable for urban horticulture
- Refining physiological requirements of tropical, seed and herbal spices for urban horticulture, vertical farming and protected cultivation on roof tops
- Fortification of bio-inoculants for pathogen control and reproductive manipulation (manipulating with fecundity) for pest control
- Marking of industry oriented production hubs

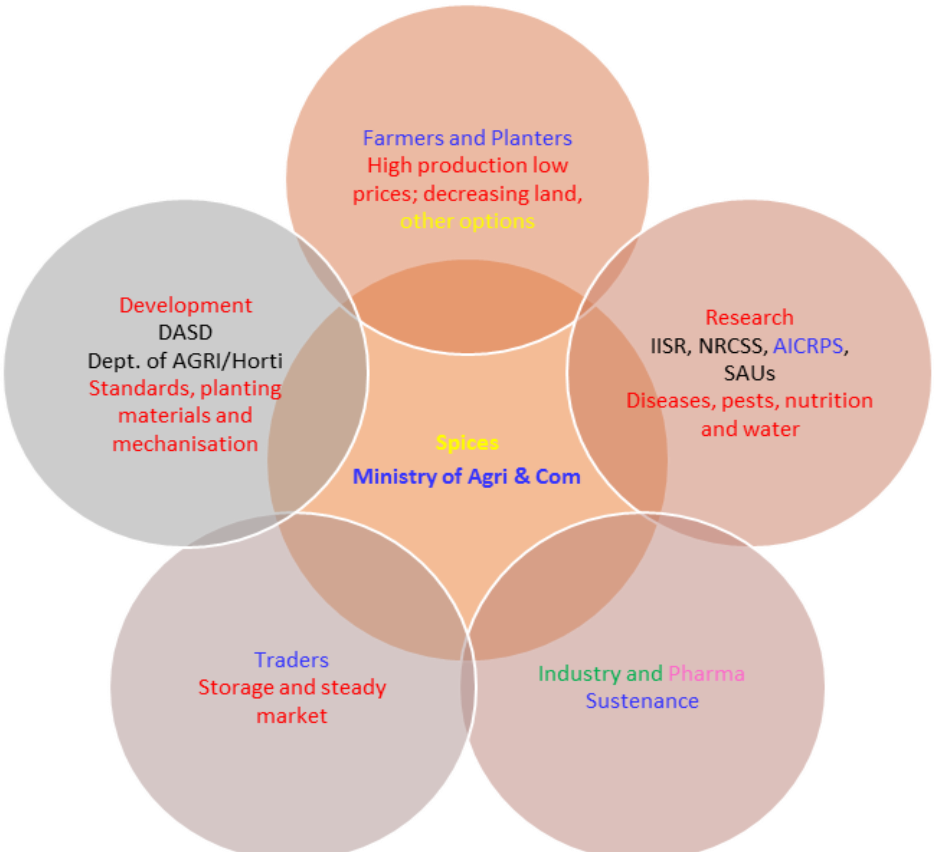
- Strict implementation of GAPs and GMPs for production and processing of food safe spices
- Knowledge, technology generation and utilization of high value compounds and nutraceutical values of spices and herbs and their use as functional foods for better health and wellness

Future targets

- Increase production of black pepper by 3 fold in next 10 years by extensive deployment of superior genotypes in coffee and tea gardens of Tamil Nadu, Odisha, Assam and West Bengal in collaboration with planters, Spices Board, DASD (MIDH) and state departments.
- Meet half of the domestic demand of healthy pesticide-free black pepper, ginger, turmeric, nutmeg, curry leaf, leafy coriander, leafy fenugreek, culinary herbal spices by deploying bush pepper, canopy reduced nutmeg grafts, tunnel cultivation, protected cultivation in urban areas, roof tops so that, the farm production is targeted only for export.
- Reduce pesticide residues in cardamom by deploying thrips resistant, vazhukka types and increase production by high yielding varieties, biannual replanting and precise mechanized fertigation with Israeli technology at least in 20% area. These will double the present production.
- Ensure monthly returns to small farmers and house holders through tunnel and off-season cultivation of leafy coriander and fenugreek supplemented by micronutrient fortification. This also helps the micronutrient deficiency (hidden hunger) in communities.
- Develop wilt and blight resistant varieties of cumin and aggressive implementation of GAPs to avoid mancozeb contamination.
- Introduce spices including seed spices as intercrop in existing gardens where ever possible and in new plantations at least in 20% area for increasing the production as well as income per unit area.
- Establishing mechanized storage, processing and BPD facilities in the model of spice parks for value addition and better remuneration in PPP mode.
- Market driven product development, identifying, isolating and patenting new high value compounds with high pharmaceutical values for low volume high value exports.
- Involvement of all concerned under one umbrella for better information and intelligence sharing for sustainable growth of all stake holders.
- Compliance to world (Codex) standards on quality and food safety.

Linkages

An effective linkage between all stakeholders is needed for optimal and equitable sharing of efforts, knowledge and profits. May be an association of all stakeholders under one working system is the futuristic need.



The vision of Indian spice industry is to become the processing hub and premier supplier of value added spices and herbs in the industrial, retail and food services segments of the global spice market by meeting the quality requirements and thus to achieve US $10 billion worth spice exports by 2025.

L2

Kokum (*Garcinia indica*)- prospects

P J Kshirsagar*, C D Pawar, P M Haldankar, Ajit Shirodkar#1& Y R Parulekar

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli
*sagartarang@rediffmail.com
[1]Chairman,Western Ghat Kokum Foundation, Goa
#shirodkars@gmail.com

The Garcinia is rich genus having more than 200 listed species out of which, 30 species are available in India and important of this are *Garcinia indica* (kokum), *Garcinia gummigutta* (Malabar tamarind),*Garcinia mangostana* (mangosteen), *Garcinia tinctoria*, *Garcinia morella*, *Garcinia cowa* and *Garcinia hombroniana* (assamauraur). Among all these species only kokum, Malabar tamarind and mangosteen are cultivated.

Area and production

Kokum (*Garcinia indica* Choisy) is one of the native underexploited tree spice. It is mostly found in Konkan region of Maharashtra, Goa, Coastal Karnataka, Kerala, forests of Assam, KhasiJayanti hills, West Bengal and Surat district of Gujarat. In spite of its incredible medicinal and nutritive properties, kokum is generally not cultivated systematically on orchard scale like that of mango, cashewnut *etc.* It is mostly found as a kitchen garden plant or mixed crop in plantations of coconut, arecanut, road side plants or in forest.

The precise statistics regarding area, production and productivity is missing for all *Garcinia* species as they are not planted in an organized pattern as that of mango, cashew, arecanut or coconut. As per a base line survey (2010), 1000 ha area is occupied by kokum in Konkan region with production of 4500 MT fruits. According to a survey conducted earlier by Chief Conservator of Forest, out of the total 46,600 kokum trees in the state of Maharashtra, 43000 trees existed in Ratnagiri and Sindhudurg districts alone. It was also reported that in South Konkan, 1,674 MT of kokum fruits were used for dried kokum rind, 757 MT for preparation of kokum syrup and 40 MT for kokum butter.

Pharmaceutical importance of *Garcinia*

Isolation and characterization of chemical

Garcinia indica extracts, especially from its rind, are rich in polyisoprenylatedbenzophenone derivatives such as garcinol and its colourless isomer, isogarcinol. The rind also contains hydroxycitric acid (HCA), hydroxycitric acid lactone, citric acid and oxalic acid. The fruit also contains other compounds including malic acid, polyphenols, carbohydrates, anthocyanin, pigments and ascorbic acid. Garcinol shows strong antioxidant activity since it contains both phenolic hydroxyl groups as well as a β – dike - tone moiety and in this respect it resembles with the well known antioxidant of plant origin *viz.,* curcumin.

Chemistry of garcinol

The principle antioxidant substance of *Garciniaindica* and other species is garcinol, also called as camboginol, which is a tri-isoprenylatedchalcone. This compound is extracted from the dried fruit rind of the plant. It scavenges 1, 1-diphenyl-2picrylhydrazyl (DPPH) free radical (3times more effectively than DL-R-tocopherol), hydroxyl radical (more effectively than DL-R-tocopherol), methyl radical and superoxide anion. Reports suggest that, garcinol can play an important role in the treatment of gastric ulcers caused by the hydroxyl radicals or chronic infection with *Helicobacter pylori,* which together with cells from gastric mucous membrane, produces hydroxyl radicals and superoxide anions. Garcinol may be a viable alternative to conventional antibiotics. Garcinol shows antibacterial activity against methicillin-resistant *Staphylococcus aureus* which is comparable to that of the antibiotic vancomycin. Although this compound has been shown to exhibit therapeutic activity against gram-positive and gram-negative cocci, mycobacteria and fungi, it has been found to be inactive against gram-negative enteric bacilli, yeasts and viruses. Garcinol exerts anti-cholinesterase properties towards acetyl cholinesterase (AChE) and butylcholinesterase. Isogracinol also shows biological activities similar to that of garcinol and has been claimed to be an anti-inflammatory and anti-tumor compound, a lipase inhibitor, an anti-obesity agent as well as an anti-ulcer agent.

Biological activities of garcinol

Antioxidant activity

Garcinol has been shown to possess antioxidant activity in the H_2O_2-NaOH-DMSO system as well as the radical scavenging activity against superoxide anion, hydroxyl radical and methyl radical, respectively.

Anti-inflammatory activity

Aberrant arachidonic acid metabolism and generation of nitric oxide radicals (NO) have been shown to be involved in inflammation and carcinogenesis. Arachidonic acid is released by phospholipase from membrane phospholipids and is further metabolized by cyclooxygenase (COX), lipoxygenease (LOX) enzymes and cytochrome pathways. Modulation of arachidonic acid metabolism by inhibiting COX and LOX enzymes has been considered as an effective approach for treating inflammation and for cancer chemo-prevention. Garcinol and its derivatives modulate arachidonic acid metabolism by retarding the phosphorylation of cytosolic through the inhibition of extracellular kinase activation and suppression of iNOS expression through modulation of tehlanus kinase signaling pathway.

Anti-cancer activity

A number of recent studies have examined the potential of garcinol, a non-nutritive dietary component, against different cancer types. In the process, a number of possibilities that explain the underlying mechanism for the chemo-preventive and/or therapeutic performance of garcinol have also arisen. The effects of garcinol and its oxidative derivatives have been investigated on the growth of cancer cells. Garcinol and its derivatives showed potent growth-inhibitory effects on all intestinal cells. Garcinol was found to be more effective in inhibiting growth of cancer cells than that of normal immortalized cells.

Garcinol's inhibition of cancer growth of various types including pancreatic, prostate, breast, leukemia, colon and its progression at different stages, is especially intriguing. Nonetheless, the full potential of this compound has yet to be elucidated. Research-based evidence pointing to the non-cytotoxic nature against normal cells, combined with potent pro-apoptotic behaviour against cancerous cells and its antimicrobial effects may be a testament to the traditional use of the plant against multiple ailments. Forthcoming data on its synegistic effect with known drugs at sub-therapeutic doses may also open up new avenues for efficient therapeutic regime without or with minimal adverse side effects. In addition, to date, no toxic effects of Garcinol have been reported, even when given orally upto 0.05% in diet. However, further investigations to evaluate the range of its therapeutic potential are required. Most of the advances in the anticancer effects of garcinol, although mechanistically exciting, have been as a result of *in vitro* studies. These may or may not be entirely reflected in an *in vivo* animal model or a clinical situation. Thus, the studies at present, although potentially very useful, call out for an immense need for carefully planned and executed studies in relevant animal models of various cancer types to confirm these findings.

Anti-HIV activity

Reports indicate that, garcinol holds tremendous therapeutic potential for different diseases including AIDS and cancer.

Anti-ulcer activity

Since hydroxyl radical is regarded as the most damaging Reactive Oxygen Species (ROS), reports indicate that, garcinol is expected to be useful for preventing diseases caused by the hydroxyl radical damages such as stress-induced gastric ulcer and NSAID drug induced gastric ulcers. Although mechanism of its anti-ulcer activity is not yet understood, it may be speculated that, the compound may scavenge reactive oxygen species on the surface of gastric mucosa, thus protecting cells from injury.

Economic importance of garcinia

The shelf life of kokum fruits is 5.4 days under ambient temperature storage. It canbe extended to 15 days when treated with waxol 12% and stored in cool chamber and up to 28 days when treated with waxol 3% and stored at 13°C and 86% RH. CFB boxes and paddy straw are good packaging material for kokum.

Value addition

The products such as *Amrit* kokum (kokum syrup), kokum *agal* (salted syrup) and *amsul* (dried rind) are traditionally prepared from the rind of fruit and oil is extracted from seeds in Konkan region of Maharashtra.

Need of standardization and advances in value addition of kokum processing

Fruit of kokum is having 3-8 seeds embedded in a red acid pulp in a regular pattern like orange segments, in the white pulpy material. Fruit rind and seed both are economical components of kokum fruit. The expected shelf life of fresh fruit is about one week. Kokum is mostly used in the form of dried rind to give acid flavour to curries and the fresh fruit juice for preparing cooling syrup and curries. It has tremendous potential in south Indian curries and it is used instead of tamarind and also has many medicinal properties.

Kokum seed is a good source of fat called as “kokum butter”. Kokum is a minor oil seed crop and butter has food and non-food applications. The oil is traditionally extracted by boiling the kernel powder in water and the oil that is collected at the top is skimmed off. The yield of oil (fat) is about 25 to 30%. Kokum fat has been reported to be used in chocolate and confectionary preparations. It is also used is manufacture of soap, candle and ointments. An ointment made out of kokum fat, white dammar resin (resin exuded by *Vateriaindica* tree) and wax is said to be effective in treating carbuncles. It is reported that Italy and some other foreign countries are importing kokum fat fromIndia for use in confectionary preparations. Kokum fruit appears to be a promising industrial raw material for commercial exploitation in view of its interesting chemical constituents.

Standardized products from kokum

Kokum syrup (Amritkokum)

The fruits are washed with clean water. The fruits are cut into two halves.Seeds and pulp are removed manually. Rind is cleaned internally and sugar is used to prepare the syrup. Kokum rind halves are placed in layers and sugar is filled in the halves. Alternate layers of kokum rind halves and sugar are put in the food grade plastic drums for 7 days. Kokum rind is extracted by osmosis. The syrup could be strained through 1 mm sieve or cloth to separate out the rind portion. The syrup is available in two variants (i) kokum syrup with no preservatives, colour, salt or water except sugar, (ii) kokum syrup with permitted preservatives and salts. (Sodium benzoate @610 mg/kg of finished product).

Kokum Amsul (Dehydrated salted rind)

Fresh kokum fruit is washed properly and cut into two halves.Seeds, pulp and the rind are separated. The seed and the pulp are mixed with around 10 percent salt. The salt solution leached out from this mixture is used for dipping the separated rind. The rind is then sun dried in trays. Next day, the dried sample is again dipped in the salt solution, which is leached on the second day from the salted seed mixture. Then the rind is again placed for drying. The process of dipping and drying is repeated for 4 to 5 times to get the *Amsul*. It has the souring qualities similar to that of tamarind, adds taste to coconut based curries and vegetables dishes. *Amsul*is popularly used with fish curries; three or four rinds are enough to season an average dish.

Kokum Agal (Salted juice)

Agal is a salted juice prepared from kokum fruit locally. Salt is added to pulp at 4 concentration levels (14, 16, 18, & 20 %). The mixture was stirred daily for seven days. After seven days the whole mixture is strained through stainless steel sieve of 1 mm and filled in presterilized bottles.

RTS drink from kokum and other juices

The T.S.S. and acidity of different juices are observed and then required quantity of citric acid and sugar was added to raise its Brix value and acidity to 20°Brix and 0.3%, respectively. Juice used is 20%.

To the remaining water**, s**odium benzoate (NaB) is added as preservative depending upon the colour of the product. After adding required quantity of sugar, citric acid and water, the product is boiled sufficiently to dissolve the ingredients. NaBis added @140 mg/kg of final product. Then the beverage is immediately filled into the presterilized glass bottles, sealed with crown corks and pasteurized for 30 minutes in boiling water, cooled, labelled and stored in cool and dry place at ambient temperature.

Squash fromkokum

For preparation of squash, 25 % juice is used. The T.S.S. is noted and required quantity of sugaris added to juice to raise its Brix value to 45°Brix. The acidity is maintained at 1.2 %. The remaining water is used for beverage preparation as explained above except that the NaB added is @610 mg/kg of final product.

Kokum butter

The oil is traditionally extracted by boiling the kernels in water and the oil which collects at the top is skimmed off. Now a days oil is obtained by solvent extraction also. The yield of oil (fat) is about 25%.

The fat is greasy to feel and whitish yellow in colour. It remains in solid state at normal room temperature. It is off-white in colour. It is used in food preparations and is helpful in skin ailments such as rashes, allergies, burns, scalds and chaffed skin. The kokum butter is used for manufacture of cosmetics, creams, soaps, confectionery, candles, *etc.*

Chemical characteristics of kokum fat

Melting point	39-43°C
Sap value	189
Iodine value	34.7-36.7
Unsaponifiable matter	1.4%
Free fatty acid -(%)	
As oleic	7.2%
Myristic	0-1.2%
Palmitic	2.5-5.3%
Stearic	52-56.4%
Oleic	39.4-41.5%
Linoleic	1.7%

Advances in value addition in kokum

Kokum rind powder

This can be a raw material for various curry preparations, ingredients in various mixes like sarbat, solkhadi, kokum RTS *etc*. The kokum rind is dried at certain temperature in a tray dryer and dried rind is ground. The ground product is sieved to get uniform particle size.

Kokum sarbat mixture

It is an instant product (ready to prepare). The kokum powder, sugar and spices are added in various concentrations and the mixture is dried in a tray dryer to get the kokum sarbat mixture.

Kokum solkhadi mixture

It is an instant product (ready to prepare). The kokum powder, coconut milk powder, milk powder, salt, sugar and spices are added in various concentrations and the mixture is dried in a tray dryer to get the kokum solkhadi mixture.

Kokum wine

The red kokum juice has about 4% sugars and can be fermented to produce wine. Kokum wine is prepared in Goa using the traditional method with commercial bakers yeast.

Kokum honey

Honey is concentrated floral nectar. So far, there are no reportson establishmentof apiculture unit in kokum plantations but if this is done then ‘kokum honey’ can be obtained with excellent medicinal qualities.

Benzophenone derivatives

Garcinol-1 is a polyisoprehylatedbenzophenone derivative from *Garcinia indica* and other species. The dried rind of *Garcinia indica* (cv. kokum) which is used as a garnish for curry and in some of the folklore medicine in India contains 2-3% garcinol. Garcinol is structurally similar to a well known antioxidant curcumin, which contains both phenolic hydroxyl groups and diketone moiety. Garcinol has been reported to possess antibiotic activities, antiulcer activities, suppressed colonic aberrant crypt foci (AFC) formation and induction of apoptosis through cytochrome C release and activation of caspases in human leukemia HL-60 cells.

Anthocyanin pigments

Kokum is a rich source of anthocyanins. The red colour in Kokum is due to presence of anthocyanin such as cyanidin 3-glucoside and cyanidine 3-sambuboside. The pigment contained in *Garciniaindica* is 1000-2400 mg/100g. Anthocyanins are considered as a potential replacementto synthetic colours because of their bright attractive hue and water solubility that allows their incorporation into aqueous food systems; they may also possess health benefits.

Hydroxycitric acid (HCA)

One of the ingredient in kokum is hydroxycitric acid (HCA), is an anti-obesity agent. It suppresses the fatty acid synthesis, lipogenesis, food intake and induces the weight loss. Fruit reduces fat, cools the body, purifies blood and lowers cholesterols. The bioactive phytochemical responsible for these attributes is para - hydroxycitric acid (para -HCA) and is found in abundance ranging from 10-30% in the rind of dried fruit of kokum.

Traditional methods of kokum fruits processing

Traditionally, fresh fruits are collected from the forest areas and are pooled and marketed.When harvested, the fruits are reddish green in colour which turns into full-redpurple colour in a day or two. The fruit has an agreeable flavour and sweetish acid taste. The normal shelf-life of the fresh fruits is about 5 days. Hence sundrying is practised for preservation. For sun drying, the fresh fruits are cut into halves and the fleshy portion containing the seeds is removed. The rind which constitutes about 50-55% of whole fruit is repeatedly soaked in the juice of the pulp during sun drying. About 6-8 days are required for complete drying. The product so dried, constitutes the unsalted kokam of commerce. A salted variety, where in common salt is used during soaking and drying of the rind is also marketed. Lonavala kokum, Pakali kokum, Khanee or edible kokum and Khoba kokum are some of the trade varieties. RTS, squash and syrup can be prepared from the juice so obtained as straight beverages.

Raw kokum juice extraction

Properly matured ripe fruits of kokum are selected and are washed thoroughly under running water.After destalking and washing of fruits, the seeds are removed from the fruits. Then the rind pieces along with juice from the fruit is passed through hand operated screw type juice extractor and the juice obtained is filtered through the four folds of muslin cloth and the clear juice obtained is used to prepare the R.T.S., squash and syrup.

For a sustainable growth of the product it was necessary to understand the linkages between all the stakeholders in the value chain namely, consumers, marketers, manufacturers and farmer producers. Our own case study is given below.

Consumer

Kokum fruit drink is as well known as salt &sugar in the households of coastal belt of Maharashtra, Goa and Karnataka with some of its associated medicinal properties but not all. In the rest of these states however the product awareness is limited. Even in this belt the drink is taken in summer only as a thirst quencher. Price affordability of the available product is not an issue.

Marketer

Given the limited awareness,it was a big challenge to promote the product, position it properly and price it correctly, creating awareness of the product's various medicinal properties first and then the necessity of bringing the product in a long shelf life package perceived to make it expensive had to be tackled. Distribution of the product in various cities in small quantities remains an issue.

Manufacturer

The manufacturing involves thermally treating the single strength fruit drink to make it bacteria free and then aseptically (without ingress of surrounding air) filling it in a specially designed package that will protect it from ingress of oxygen, thereby offering a very long shelf life. This processing capability and packaging technology is available from a company called Tetra Pak who are world leaders is liquid food packaging. The processing and packaging plant works on a continuous basis throughout the day with planned intermittent cleaning in place. The smallest packaging plant has a throughput of 1500 liters per hour which translates on 20 hours and 300 days in a year basis to 9 million liters or 45 million packs of 200 ml size.

Farmer/producer

Kokum fruit is effectively available for just over a month in a limited geographical area. Most of the fruit is even today brought in by the gatherers and organized cultivation is still a daydream. The fruit does not command a price because there is no demand and is sold currently for a throwaway price. When a processor approaches the cultivators/ gatherers the price quoted is awesome and quantity is not guaranteed. A farmercame in contact with an NGO run pilot project supported by the collector of Sindhudurg, who helped us collect the dried fruit rind through the self help groups trained by them. We paid the entire price for the produce in advance and in such numbers that were hitherto unheard of. A proper understanding of the linkages enumerated above guided the making of our business plan and product strategy.

Product recipe

Departing from the conventional method of syrup to RTS, we decided to add clarified sugar syrup at the manufacturing plant. The excellent quality of dried kokum rind made it possible to retain the anthocyanin in the final drink eliminating the need for any added colour. The Tetra Pak processing and packaging technology made it possible to do away with any added preservative or flavour.

Package design

A professional designer is commissioned to create a proper image of product and to display the product characteristics.

Product positioning

The backbone of our product is the medicinal properties that it offers, so we positioned it as a "Functional Food" and decided to promote it as an everyday drink.

Product promotion

A website, www.idrinksant.com is launched to describe the product in detail and articles written by manufacturersare posted in it. Feedback on value proposition help to fix a price of Rs. 15.

Product manufacturing and raw material sourcing

A commercial contract was put in place with the owners of Tetra Pak Processing and Packaging Plant. Packaging material in large quantities and raw material in adequate quantities were purchased by paying in advance.

Product distributors

The product is available today through the efforts of our distributors in the retail outlets of Mumbai, Pune and some other cities of Maharashtra. The product is also available in Singapore and Dubai and has been test marketed in the United States of America. A small beginning has been made and the product is kept alive for over a year from its launch time. A lot needs to be done yet to communicate the excellent product properties of this drink.

The issues that need to be effectively communicated are

The drink is rich in antioxidant properties and when measured on ORAC scale it comes at the top. Taken every day like milk and tea, it brings immunity to a variety of diseases. The drink is very well suited as a remedy for urinary tract Infection. It is a very good agent for weight reduction despite the sugar used in it. The drink is undoubtedly proven as an anti acidity drink and a natural thirst quencher. The drink is most suitable for IT professionals who have to spend long hours in front of the computers that causes generation of heat in their bodies causing acidity.

Need for standardization of traditional processing methods

Presently kokum syrup, kokum *Agal* and Kokum *Amsul* are being prepared traditionally in Konkan region. Problems associated with the traditional processing methods are

- Products prepared are lacking in uniformity in product quality. The final product produced depends on the experience of a person who is preparing the product. Quality of the final product varies with the persons who are preparing it.
- Maintaining the cleanliness during the preparation of the products is difficult in the traditional processing.
- The developed products (kokum syrup, kokum *Agal* and kokum *Amsul*) need to be packed in a suitable packaging material so that it could be kept safe storage limit for longer duration. In traditional processing methods less emphasis is given to the packaging of these products. The packaging material for which these products are to be packed needs to be standardized.
- Kokum seeds are extracted efficiently so that more recovery of the kokum butter is possible.
- The nutritional composition of the food products need to be mentioned while promoting the products.

- Storage of these products needs to be studied and duration for storing these products needs to be determined so that its safe storage limit is to be fixed.
- HACCP principles need to be carried out during preparation of these products so that these could be prepared as per the international standards. To fulfil the gaps of the traditional processes and to overcome the problems associated with these methods, there is a need to standardize these products. An attempt has been made to standardize these techniques with scientific approach. Also some new products have been developed from Kokum *i.e.* kokum rind powder, kokum sarbat mixes, kokum solkadhi mixes *etc.*

Varietal improvement

Greater variability among the genotypes in respect to yield and quality parameters, dioeciousness, dominance of tropism in vegetative propagation and harvesting at the onset of rainy season are some of the foremost important obstacles for its acceptance as a commercial crop. Presently the research work on production technology is being conducted at Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, ICAR research complex for Goa, University for Agricultural Sciences, Dharwad and at ICAR-Indian Institute of Spices Research, Kozhikode.

Kokum is a dioecious plant and hence obligatory cross pollinated, due to which a lot of variability is observed in existing population. The variability with respect to morphological features such as leaf parameters, flowering, fruit set, fruit shape, colour, physicochemical composition and yield have been reported.

Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, at various research stations have conserved more than 300 types of kokum. Two improved kokum varieties namely Konkan Amruta and Konkan Hatis have been released by Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli.

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Strategies for sustainable spice production - The way forward

M Anandaraj

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
anandaraj@spices.res.in

Spice crops, in general, are set to make impressive forays during the coming decade. The production was 59.08 lakh tonnes from an area of 31.63 lakh ha during 2013-14. In terms of export, a total of 893.92 thousand tonnes of spices and spice products valued Rs. 14899.67 crore (US$ 2432 million) have been exported from the country during 2014-15 (E), as against 817.25 thousand tonnes valued Rs. 13735.4 crore (US$ 2267million) in 2013-14, registering an increase of 9% in volume and 7% in value terms. Value added products also form an integral part of our export basket. Hence, value addition/secondary agriculture would be the major agenda of Indian Council of Agricultural Research (ICAR) and the Spices Board. While ICAR is focusing on high value compounds from plants, especially spices as a major research platform in the coming years, the Spices Board hopes that, 75-80% of the total export revenue target of $3 billion over the next five years will come from value addition in mint, chillies, pepper, ginger, turmeric, cumin, garlic, spice oils and oleoresins, nutmeg and cardamom.

India is known as the home of spices and has consistently been the major player in the production, consumption and export of spices (Table 1). The world food industry overly relies on these high value low volume commodities to produce a range of products with variations that are tailor made to meet the consumer needs. Besides, spice crops provide natural colours and flavors that are superior to cheap artificial ones and are considered critical to health conscious consumers. No wonder, history shows that spices have played a hugely important role in the European Renaissance and supplier for most of the countries in Europe was India.The estimated growth rate for spices demand in the world is around 3.19%, which is a shade above the population growth rate. Though every state/union territory in the country grows at least a few spice crops, Kerala, Andhra Pradesh, Gujarat, Maharashtra, West Bengal, Karnataka, Tamil Nadu, Orissa and Madhya Pradesh,Rajasthan and North Eastern states are the major spices producing states.

Table 1. Present status of area, production and productivity of major spice crops (2013-14)

Crop	Area (thousand ha)	Production (thousandtons)	Productivity (kg/ha)
Black pepper	123.8	50.87	410.9
Cardamom	92.8	21.28	229.3
Ginger	132.6	655.00	4939.7
Turmeric	232.6	1189.90	5115.6
Nutmeg	18.9	12.78	676.2
Cinnamon	2.8	5.05	1803.6
Clove	2.1	1.07	509.5
Coriander	447.1	313.6	701.4
Cumin	858.9	513.8	598.2
Fennel	54.2	70.12	1293.7
Fenugreek	70.1	65.94	940.7
Ajwain	89.6	26.67	297.7

Major challenges

The fact that the livelihood security of significant number of small holder producers is dependent on this sector makes it imperative that the spice crops economy shows vibrant growth. Despite these efforts, the yield levels of some of the spice crops in the sector like cardamom, black pepper and fennel continue to be well below the global average productivity level.The spices sector has shown considerable interest to adopt modernization, visible across the plantations showing revised interest in adopting advanced technologies in production and post harvest practices, level of technology adoption and cultivation practices. The small size of the holdings presents both challenges and opportunities for sustainable growth. The technologies available, especially in mechanization of operations, are often not adopted in small holdings. This presents considerable challenges for increasing the efficiency of production. Volatile prices prevailing in the international markets often drives the interest of the growers and sometimes increase in demand for the products did not translate to higher prices due to the rise in productivity of the crops. Apart from these, the concerns about the sustainability of the production practices followed, the unexploited latent potential for value addition and the need to enhance the relevance and role of research and developmental institutions working in the sector are some of the key areas of concern.

The major risk factors involved in spices sector are:

- Climate change resulting in drought/excess moisture, high/low temperature during critical periods, *etc.*
- Emergence and epidemics of pests and diseases
- Soil fertility – high acidity, poor drainage, low nutrient status, *etc.*
- Competition from other major spice producing countries in the International market.
- Shifting of interests of growers to more profitable/less risky crops.
- Adulteration of spices
- Cyclic market fluctuations at international and national levels
- Pesticide residues and mycotoxin contaminants in the products and lack of MRL and ADI standards in some of the pesticides used in spices

The fast growing food industry depends largely on spices as taste and flavour makers. Health conscious consumers in developed countries prefer natural colours and flavours of plant origin to cheap synthetic ones. Developed countries are the major markets for our exports and it is imperative that the product conforms to the quality standards set forth by the importing country. Besides the intrinsic parameters like the essential oils and oleoresin content, the presence of extraneous matter, moisture and microbial contaminants decide the quality of the produce. Hence, spices exported into these countries should be free from bacterial contamination, mold, mycotoxins, harmful chemicals including pesticide residues and other pollutants, insect infestation and filth contributed by animals, insects or insanitary conditions in the farm, warehouse, package or carrier. The estimated growth rate for spices demand in the world is around 3.2%, which is just above the population growth rate. The forecasted population increase is up to 1619 millions in 2050 with increased GDP and per capita food spending. As spices are of high value with nutraceuticals compounds, its per capita demand may increase many fold by 2050. The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148 g, 53 g, 1.22 kg and 1.63 kg, respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7-5.7 folds from the present levels. 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.

Technological advancements

Novel and smart delivery method of biocontrol agents through encapsulation

A perfect biofertilizer formulation heretofore does not exist and each type (talc, liquid *etc.*) has its own advantages and limits. Nevertheless, a promising advancement has been the development of techniques that allow encapsulating the microbial strain in a nutritive shell or capsule and deliver them to the targeted site. While encapsulating techniques have been fairly successful in the laboratory, attempts to emulate the performance in the field have been largely unsuccessful. Therefore, presently no such commercial products are available in the market. ICAR-IISR has made a significant breakthrough in the successful encapsulation and delivery of a plant growth promoting rhizobacteria for growth promotion and disease control in ginger (Fig 1). The encapsulation process is simple, does not require sophisticated equipments and comes at low investment. Other advantages include reduced cost and easy handling and transport, no harmful by products, less requirement of inorganic and inert material, storage at normal temperature and more importantly, enhanced shelf life. Besides, this encapsulation technique can be used to deliver all kinds agriculturally important microorganisms *viz.*, N fixers, nutrient solubilizers/ mobilizers, PGPR, Trichoderma, Burkholderia*etc.* Patent for this delivery process has been filed (Application No.3594/CHE/2013 dated 13/08/2013) and the technology is being commercialized by providing non-exclusive licenses to prospective entrepreneurs.

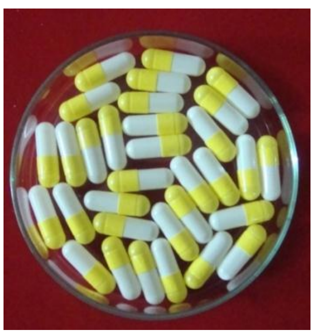


Fig. 1. Gelatine capsules containing PGPR *Bacillus amyloliquefaciens* IISR GRB 35

Improved soil less method (Pro-tray) for production of healthy planting material of ginger

The major diseases in ginger are soft rot caused by *Pythium* sp. and bacterial wilt caused by *Ralstoniasolanacearum*. These pathogens are both seed and soil borne. If disease free planting materials are raised it will reduce the problem by half. 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 (Fig. 2). 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 planting 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. The advantages of this method include less planting material requirement, 500-750 kg ha^{-1}, hence saving in seed cost and only $1/5^{th}$ of seed material is needed. It aids in 98–100% field establishment and is suitable for high production technology, early/delayed planting and ensures high cost: benefit ratio.

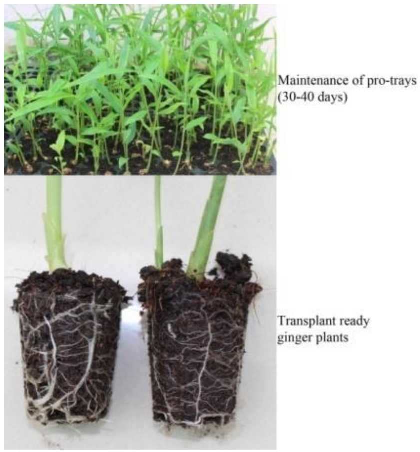


Fig. 2. Production of healthy planting material of ginger using pro-trays

Site-specific nutrient management plans and micronutrient formulations for targeted yield in major spices

Majority of soils in the spice growing areas are encountering soil fertility issues due to acidity, nutrient imbalances and deficiencies of secondary and micronutrients that becomes yield limiting. Nutrient management plans for spices based on soil test values have been standardized for conventional, integrated and organic farming systems. Besides crop specific, soil pH based micronutrient mixtures for foliar application in black pepper, cardamom, ginger and turmeric crops which guarantees 10 to 25% increase in yield and quality have also been developed. An innate advantage of these mixtures is that they can also be used in organic agriculture and therefore are benign and environment friendly. The technology comes at very low cost and hence is very farmer friendly. The micronutrient technologies have been licensed to entrepreneurs for large scale production and commercialization.

Vertical column method for quality black pepper planting material production

The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2 m column having one foot diameter made with plastic coated welded wire mesh (size 4 cm) filled with composted pasteurisedcocopeat and vermicompost @3:1 ratio fortified with bio-control agent *Trichoderma harzianum* in poly house fitted with fan and pad system maintaining temperature of 25 to 28°C and relative humidity of 75% to 80% with misting units. Eight to ten cuttings can be planted around each vertical column. The cuttings are allowed to trail (Fig. 3a) on the column and it would take four months to reach the top and produce more than 20 nodes. Each vine invariably produce lateral reproductive branches within three months time at 12^{th}–15^{th} node, whereas, vines allowed to grow horizontally on the bed with same medium also produce similar number of nodes but will not have lateral fruit bearing branch. The top 5-7 nodes have lateral branches also (Fig. 3b.). The top 5 nodes can be used as orthotropic shoots as is done in Malaysia and Indonesia to induce fruiting laterals from the base.


3a

3b

Fig. 3. Black pepper on vertical column (3a) with lateral branch (3b)

Growing the vine on vertical column can be effectively utilized for the production of three types of planting material *i.e.*, single node cuttings, top shoots with lateral branch (use of top shoots for field planting is having advantage of producing fruit bearing branch from the base of the support and start yielding early) and reproductive branch (laterals or plagiotropes) which can be used for production of bush pepper kept in the house or gardens. In four to five months time, on an average 150 single nodes (15 cuttings per vine × 10 vines around the vertical column) per column, one or two laterals and 10 top shoots can be harvested. In a poly house of size 320 sq.m (20 × 16 m), one can accommodate 300 such columns. In a year three harvests can be made. These cuttings can be rooted further for field planting using pro-trays. The advantage of vertical column method is one can get three type of cuttings *viz*., normal single node cutting, laterals and top shoots.

Growing black pepper plants on columns makes the clinging roots also take up the role of absorption and the rate of growth is enhanced. Since it is in the polyhouse with misting to control temperature and humidity growth is fast in hot humid climate. The misting units switched on periodically gives adequate moisture and separate irrigation is avoided. As the lateral production undertaken in column after about 10 nodes, one produce three types of planting material. Each column can give 10 orthortropic shoots of 5 nodes each; 20-30 lateral branches that can be made into bush pepper and 100-120 single node cuttings in four months time. As the process is repeated one can harvest minimum of three cycles or maximum of four cycles. The lateral cuttings needed for bush pepper can be developed without sacrificing fruiting laterals from the field and the nursery itself laterals can be produced. This vertical column method is faster and efficient as it produces three types of cuttings.

DNA barcoding technique to detect adulterant in spice products

Adulterants of any nature in exported commodities also adversely affect the legendary fame of Indian spices and thereby hamper the nation's prestige. DNA barcoding has been put into use to detect the plant based adulterants in traded spices such as black pepper powder, cinnamon and turmeric at ICAR-IISR. Though many vegetative adulterants such as papaya seed, wild *Piper* species *etc.* are reported as adulterants in traded black pepper, DNA barcoding method could detect chilli as an adulterant in traded black pepper for the first time. This work has attracted international attention. Probably unscrupulous elements may be finding it lucrative to recycle the exhausted black pepper (the black pepper left after the extraction of the pungent principles) as value added black pepper (powder), fortified with other pungent substances like chilli.

Of late, *C. verum* barks are adulterated with a rougher, thicker, cheaper and less aromatic bark of the morphologically similar *C. cassia* (syn*. C. aromaticum*) having a bitter and burning flavor. Our barcoding technique could detect the presence of *C. cassia* in two of the market samples out of the five studied thereby confirming the presence of *C. cassia* adulteration in commercial samples of true cinnamon. Similarly in turmeric, we could detect the presences of *Curcuma zedoaria* and cassava starch in one sample each out of the ten branded market samples of turmeric powder studied using DNA barcoding.

Whole genome sequencing and annotation of Phytophthora infecting black pepper

De novo hybrid assemblies using sequence reads from two NGS platforms (Illumina and Roche/454) were made for two isolates of *Phytophthora*. The *de novo* hybrid assembly of two next-generation sequencing (NGS) technologies (Illumina and Roche/454 sequencing) yielded 63.8 Mb genome size at an N50 contig length of 4724 kb, with contig length ranging from 200- 42775 for smallest and largest contigs, respectively. The *de novo* hybrid assembly gave out 32044 contigs and 47280344 bases using Newbler Assembler. A reference assembly was also conducted to compare *P. capsici* genome of joint genome institute and identity was 95.35% with an average read depth of 50X. Structural annotation was carried out using *ab-initio* gene prediction methods and an approximate of 22,358 coding sequences and 54485 exons were obtained. Simple sequence repeats (SSR) analysis revealed that there are 1344 SSRs out of 32044 contig sequence analysed. Whole genome alignment and comparison with reference genome revealed 1,298,146 SNP sites; 917 genes were common with reference genome of *P. capsici* (JGI) and 5501 genes are unique in *P. capsici* isolate of IISR. Blast homology based functional annotation revealed the presence of various proteins important for the survival of *Phytophthora* sp. in host plants and virulence associated proteins crucial for its infection. The newly assembled genome of *P. capsici* was structurally and functionally annotated to curate all possible gene by gene information.

Business planning and development unit

The institute has been offered with a business planning and development unit (BPD) under the National Agricultural Innovation Project (NAIP) sponsored project and facilities were established by investing Rs. 1.16 crores. The BPD unit is a business incubation centre designed for the agricultural sector to promote entrepreneurs aided by the vast research and development capabilities resident with ICAR. BPD Unit will identify in the first place potential technologies of ICAR-IISR and shall equip entrepreneurs to create them into profitable business ventures. The research and development system will act hand in hand to facilitate the extension of the technologies from their place of origin to Agri-business ventures. Being the initial years of inception now the BPD is giving more impetus to entrepreneurship development and commercialization with respect to technologies developed by IISR. However, in the long run, the unit will act as a co-incubation centre to facilitate commercialization of technologies from sister institutes of ICAR and from innovators outside ICAR.

The highlight of the BPD unit at IISR is the spice processing facility established at ICAR-IISR Farm, Peruvannamuzhi. The unit was commissioned in July 2014 and is now ready for operation and is compliant with national and international quality requirements. This unit was envisaged to promote entrepreneurship development and improve the competitiveness of the spice industry through scientific training, capacity building and implementation of ISO standards for spice processing. The unit is equipped with state of the art facilities for cleaning and grading black pepper and production of curry powders. This unit will not only cater to the needs of the farmers in the spice growing belt where it is situated but will also serve as a model unit for the benefit of spice growers and entrepreneurs all over the world. ICAR- IISR periodically organizes entrepreneurship development programme (EDP) for the stake holders to identify suitable entrepreneurs for steering forward the operations of the processing facility.

The way forward

The main researchable areas should include

- Conservation of genetic resources, bar coding and crop improvement using cutting edge technologies and science of '*omics*'
- Increasing productivity of spices through
  - Quality planting material production and supply
  - Productivity enhancement through better input management/precision farming systems
  - Ideotype development for quality and climate resilience
  - Bio-risk management
  - Reduce labour shortage by inventing new methods of harvesting black pepper
  - Protected cultivation of spices for availability in the season
- New market oriented technologies for secondary agriculture and value addition
- Exploiting the potential of spices as nutraceuticals
- Effective transfer of technologies to target groups

There is great scope to improve the productivity of major spices as the potential yield realized in the research station and at the progressive farmers plots are very high and well above the national average. Spices cultivation is spreading to non-traditional areas and is being expanded in the North Eastern Hill Region (NEHR) hence, need to develop region/location-specific varieties and technologies for improving the production and productivity of spice crops in these areas.The realization of this potential yield can be made through dissemination of developed technologies like promising varieties, high production and pest and disease management strategies. In addition, research programmes are to be intensified in the area of high value compounds in spices for possible drug formulations and to develop Nutrigenomics and Pharmacogenomics as a composite technology in the area of bioactive compounds. India can withstand the competition only by increasing productivity and reducing cost of cultivation leading to low cost per unit of production. Sound technology background on precision farming, protected cultivation and intensive farming including urban horticulture can meet this demand. A well reasoned and cohesive application of cutting edge research, institutional support for development and creative policy initiatives can ensure a vibrant spices sector in the country.

L4

Spices prospects and retrospects- Accent on NE Region

V A Parthasarathy

ICAR Adjunct Faculty in Horticulture (TNAU & IARI) and
Former Director, ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
vapartha@gmail.com

Spices are high value and low volume commodities of commerce in the world market. The fast growing food industry world over depends largely on spices as taste and flavour makers to create variation in their product line. Health conscious consumers in developed countries prefer natural colours and flavours of plant origin to cheap synthetic ones. Thus, spices play more important role in the food industry world over. The estimated growth rate for spices demand in the world is around 3.19%., which is just above the population growth rate. India has been a traditional producer, consumer and exporter of spices. There are about 109 spices listed by International Organization for Standardization and India grows about 60 of these spices. Almost all states in the country produce one or other spices. Spices exports have registered substantial growth during the last five years, registering an annual average growth rate of 21% in value and 10% in volume and India commands a formidable position in the World Spice Trade. During the 2012-13, a total of 6,99,170 tons of spices and spice products valued Rs.11171.16 crore (US$2040.18 Million) has been exported from the country as against 5,75,270 tons valued Rs.9783.42 crore (US$ 2037.76 Million) in 2011-12, registering an increase of 22% in volume and 14% in rupee terms of value.

The North Eastern Region of India comprising the States of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim has vast bio-diversity and is a home to a unique but fragile ecology. It constitutes about 8% of the country's geographical area and 4% of its population. The North-Eastern Region has the total geographical area of 2,62,185 Sq. Kms. Arunachal Pradesh having an area of 83,740 Sq.Km is the largest State while Tripura with 10,490 Sq Km areas is the smallest state of the region. About 70% of the region is hilly and the topography varies within each state. Mountains and hills cover most of Arunachal Pradesh, Manipur, Mizoram, Nagaland, Meghalaya, Sikkim and about half of Tripura, one-fifth of Assam. The rainy season in this region generally commences from March and lasts till the middle of October. The total annual rainfall varies significantly in the region. In Khasi and Jaintia Hills, the annual intensity of rainfall reaches the maximum of about 1080 cm around Cherrapunjee and Mawsynram (having highest rainfall in the world). It is significantly low in the rain shadow area of Nagaon district in Assam.

The North Eastern region is in 6 agro climatic zones. North East region is one of the richest reservoirs of genetic variability and diversity of different crops *i.e.* various kinds of fruits, different vegetables, spices, ornamental plants and also medicinal & aromatic plants.

Six Agro-climatic zones

- Alpine zone : More than 3500 m asl
- Temperate and sub-alpine zone : 1500 – 3500 m asl
- Sub-tropical hill zone : 1000 -1500 m asl
- Sub-tropical plain zone : 400 – 1000 m asl
- Mild-tropical hill zone : 200 – 800 m asl
- Mild-tropical plain zone : 0 – 200 m asl

Characteristics of the North East Region and Himalayan States

- Hilly terrain and poor connectivity & accessibility
- Extremely fragile ecosystem with huge biodiversity
- Shifting Cultivation (Jhum)
- Very small holdings and land tenure system
- Low productivity under traditional cultivation practices
- Poor industrial base except that of Tea
- Higher literacy with poor employment opportunities
- Very large number of research and academic facilities has come of late
- Favourable agro climate for a wide range of horticultural crops (high humidity and high intensity of light) but only 18% of the cultivated area is under horticulture crops
- Well distributed rainfall & rich soil

Peep into history of spices!

In ancient times, spices were as precious as gold; and as significant as medicines, preservatives and perfumes. Spices have been used since time immemorial to enhance or vary the flavours of foods. One of the first uses of spices was for religious purposes such as for incense, embalming, in sacrificial rites and as charms, perfumes, or medicines. In the middle Ages, spice became a luxury item, a commodity so valued that it was accepted as currency. And is it too outlandish to claim that America was discovered due to spice-after all, it was the search for trade routes to India's valuable spices that inspired explorers like Columbus (Brown, 2003). The resultant spice trade is an integral part of the history of the rising and falling empires of India, China, Italian city states like Venice, Holland, England and Portugal. From ancient times to the present, Asia has been well known as the 'Land of Spices'. The Maluku Islands of Indonesia, also known to English speakers as the Moluccas, are referred to as the 'Spice Islands'. For the Indians who produce and export the majority of spices for world markets, the term 'Spice Bowl of the World', is applied to the State of Kerala. Many of the world's finest spices like black pepper, cardamom, nutmeg, ginger and turmeric have been produced in Kerala.

The fame of Indian spices is older than the recorded history. The story of Indian Spices is more than 7000 years old. Centuries before Greece and Rome had been discovered, sailing ships were carrying Indian spices, perfumes and textiles to Mesopotamia, Arabia and Egypt. It was the lure of these that brought many seafarers to the shores of India. Theophrastus described black pepper and long pepper (*P. longum* L.) in the 4th century BCE. The powerful Chola Kings before 100 BCE supposedly took pepper to Indonesia (Parthasarthy *et al*. 2007). Long before Christian era, the Greek merchants thronged the markets of South India, buying many expensive items amongst which spices were one. Epicurean Rome was spending a fortune on Indian spices, silks, brocades, Dhaka Muslin and cloth of gold, *etc*. It is believed that the Parthian wars were being fought by Rome largely to keep open the trade route to India.

Spice trade

World trade in spices has shown a consistent upward trend over the past 25 years. According to UNCTAD world spice trade was amounted to US$300.6 million during 1970-75 and rose to US$ 2449.191 million in 2002. The Indian spice export was to the tune of 2.25 lakh tonnes valued at Rs. 1213 crores during 1996-97. But presently, the spices export has crossed the billion US $ mark during 2007-08 with 4.44 lakh tonnes quantity valued at Rs. 4435 crores from 3.73 lakh tonnes valued for 3576 crores during 2006-07. And it has continued its growth during 2008-09 also with 4.70 lakh tonnes spices export worth of Rs. 5300 crores, an all time high both in terms of volume and value of countries spices export. The export has shown an increase of 19% in value and 6% in quantity compared to 2008.

Area, production and productivity

The country is producing around 3.94 million tonnes of spices from 2.41 million hectares of land. During the last three decades (for which data is available) the production has become nearly three times due to area expansion and higher productivity. Value of spices exports from the country has experienced five-fold increase during the same period. In the total spice economy various spices have contributed depending on their importance. Though the country is the homeland for many spices, productivity level attained in most spices is very low, when compared to other competing countries. This recorded low productivity led to consequent low production and productivity efficiency for India in the world market for spices. Over the years, India's share in world spices market has not appreciated much and its monopoly as a supplier of spices is threatened by countries like China, Brazil, Vietnam, Pakistan, Egypt, Turkey and other African and Caribbean countries. India also faces shortage of exportable surplus because of increasing domestic demand. Sharp fluctuations in the quantum and value of exports and in the unit value realization have characterized the spices trade in recent years.

Among export of different spices maximum share was from Chilli (40%) followed by cumin (11%), turmeric (11%), coriander (6%) and black pepper (5%) during 2008-09. However in terms of value mint products and spice oil & oleoresins contributed for 44% of the total export earnings. Chilli, cumin and black pepper contributed 20%, 10% and 8%, respectively for the total export earnings. India's share in World Trade was 2.8 lakh tonnes valued at 172.5 crores. India remains a major player in spices trade. On a global scale, the annual growth rate in spices consumption is estimated around 10%. At this rate, the world trade by 2020 will be around 24.2 lakh tonnes. Among spices, the major ones, which contribute to export, are black pepper, cardamom, chillies, ginger, turmeric, coriander, cumin, celery, fennel, fenugreek, garlic, curry powder, spice oils and oleoresins. During the past few years, large cardamom, turmeric, seed spices and curry powder registered substantial increase in export earnings.

Spices in North East India

Among the different spices crops that are grown in the region are ginger, turmeric, chillies and bay leaf. Though recently introduced, the region has a potential for commercial cultivation of black pepper, cumin, large cardamom and saffron. Three commercial crops need mention in this respect *viz.* ginger, turmeric and large cardamom. A number of local cultivars exist in north eastern region. In case of turmeric the local variety 'Lakadong' grown mainly in Jowai area of Meghalaya has shown high curcumin content (7.45%) as compared to 6.7 and 7.2 in high yielding varieties like G.L.Puran and Daghi. The potential of ginger in NE is huge. Nearly 60% of India's ginger comes from this region. The native ginger from this region has been used by many research institutes and they have taken new avatar in the form of Improved varieties. The large cardamom (*Amomum subulatum* Roxb.) is an important spice crop growing abundantly in Sikkim and in some parts of Arunachal Pradesh. The total annual production of dry capsules is to the tune of 4,000 tonnes from these states. Some other species like *A. delabatum* and *A. aromaticum* also exist. A wild type of *Ammomum* known as 'Belak' in Arunachal Pradesh has got very small sized seeds, although the capsules are large. If the astringency of its seeds could be reduced, it will find scope for cultivation.

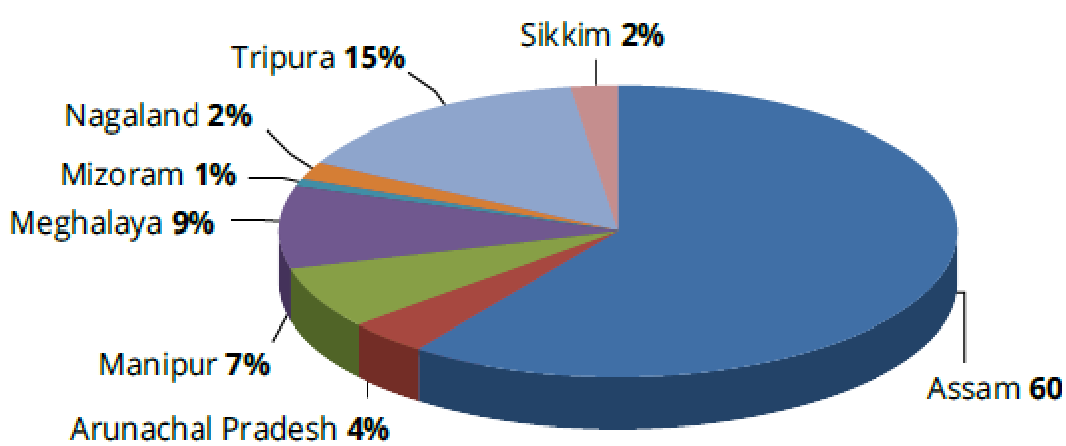
It is generally believed the Star anise (*Illecium verum* L.) is not grown in India. But there are areas in Arunachal Pradesh where the wild relatives of *Illecium* grow wild in the forest. The plant, *Illicium griffithii*, found in three districts of the Himalayan state, is a source of shikimic acid, the raw material used to manufacture oseltamivir, an anti-viral drug for influenza. Most of the world's supply of shikimic acid currently comes from China. *Illicium griffithii*, locally known as *lissi* in Monpa dialect, grows in large quantities at an elevation of 2,500 meters and above in Tawang and West Kameng districts. The Botanical Survey of India recently spotted it in Talle Valley wildlife sanctuary of Lower Subansiri district. Studies suggest that this botanical marvel in Arunachal Pradesh has slightly higher levels of shikimic acid than the plants used to extract this chemical in China. A 10.5 per cent level of shikimic acid is sufficient to support commercially viable production. The Arunachal Pradesh variety contains 12% to 14%. This indicates the possibility of growing the commercial Star anise in Arunachal Pradesh.

The entire NE Regions is Horticultural biased in its agriculture. This is amply shown in the Table 1 & Fig. 1.

Table 1. Percentage of area under horticulture in N.E. States

State	% area under horticulture
Arunachal Pradesh	31.70
Assam	14.04
Manipur	43.48
Meghalaya	30.09
Mizoram	60.57
Nagaland	7.70
Sikkim	45.76
Tripura	30.03
Total	**18.91**

Source: Agricultural statistics at a glance, Government of India, 2012



Source: *ISAP Analysis & NHB Data, 2011*

Fig. 1. State-wise contribution to horticulture in NER

The Government of India Technology Mission for North East (TMNE) has brought about a welcome change in area and production of various horticultural crops. Table 2 indicates the increase in area and production of spices in the last decade. There has been an increase of 27% in area and 68% in production. This is remarkable among the horticultural crops (Fig. 2).

Table 2. Increase in area and production of spices in NE region

State	2001- 02		2009-10	
	Area (ha)	Production (tons)	Area (ha)	Production (tons)
Arunachal Pradesh	560	784	6071	3190
Assam	83125	191040	98892	297862
Manipur	8465	37985	12667	104095
Meghalaya	200	1086	1210	2685
Mizoram	8507	85645	19400	101350
Nagaland	1491	6516	11564	46855
Sikkim	22100	22650	7999	23360
Tripura	184	713	680	2313
Total	124632	346239	158484	581770

Source: TMNE/DASD

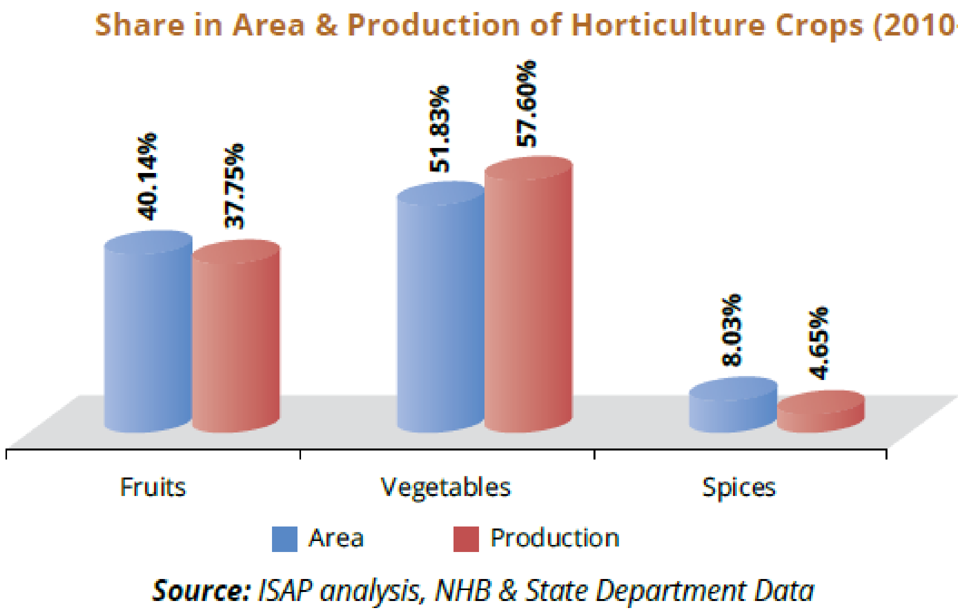


Fig. 2. Share in area and production of horticultural crops in NE region

The NE region is a tiger woken up. If we have to achieve the target for the country in spice production (Table 5) we have to look up to NE region only. While it is difficult to increase area under different crops, there is ample opportunity to increase the area under vertical and mixed farming conditions. Black pepper is an example. There must be mission mode approach for black pepper. There are about 5 lakh hectares under tea and each hectare has about 125 shade trees which could be used to train black pepper. If all tea gardens are convinced about this, we would be able to produce over 50000 tonnes of black pepper which would be around 75% of our total production. The productivity of black pepper is high in NE region.

Looking at spices differently!

Do spices only flavor the curries? They have better roles than what one imagines (Table 3). It is also said that Indian spices and her famed products were the main lure for crusades and expeditions to the

East. However, compared to other goods traded, spices took up less cargo space, so their popularity was higher than bulkier products. Ancient peoples such as the Egyptian, the Arab and the Roman made extensive uses of spices, not only to add flavor to foods and beverages, but as medicines, disinfectants, incenses, stimulants and even as aphrodisiac agents. No wonder they were sought after in the same manner gold and precious metals. Spices like turmeric and paprika, are used more for imparting an attractive colour than for enhancing taste. Most of the spices also find place in various medicines. The extracts are used as infusions, decoctions, macerations, tinctures, fluid extracts, teas, juices, syrups, poultices, compresses, oils, ointments and powders.

Table 3. **Uses of spices**

Basic function	**Major spices**	**Other related spices used**
Flavouring	Parsley, cinnamon, allspice, dill, mint, tarragon, cumin, marjoram, star anise, basil, anise, mace, nutmeg, fennel, sesame, vanilla, fenugreek, cardamom, celery	Garlic, onion, bay leaves, clove, thyme, rosemary, caraway, sage, savory, coriander, pepper, oregano, horseradish, Japanese pepper, saffron, ginger, leek, mustard
Deodorizing/ masking	Garlic, savory, bay leaves, clove, leek, thyme, rosemary, caraway, sage, oregano, onion, coriander	
Pungency	Garlic, savory, bay leaves, clove, leek, thyme, rosemary, caraway, sage, oregano, onion, coriander, Japanese, pepper, mustard, ginger, horseradish, red pepper, pepper	Parsley, pepper, allspice, mint, tarragon, cumin, star anise, mace, fennel, sesame, cardamom, mustard, cinnamon, vanilla, horseradish, Japanese pepper, nutmeg, ginger
Colouring	Paprika, turmeric, saffron	

Inherent qualities of Indian spices

Spices have been used for their flavor, aroma and color and as preservatives for thousands of years. Their use in traditional systems of medicine dates back to centuries. Today there is greater scientifically validated knowledge on spices phytochemistry, therapeutic effects of their bioactive principles and mechanism of action. Most of the medicinal properties are attributed to the secondary metabolites – the essential oils and oleoresins – present in spices, a large number of which have been identified (Table 4). The various phytochemicals include flavonoids, terpenoids, lignans, sulfides, polyphenolics, carotenoids, coumarins, saponins, plant sterols, curcumins, phthalides *etc.* Several chemical constituents in spices *viz,* most of the secondary metabolites, pungent principles, volatile oil compounds, alkaloids *etc*. are responsible for the numerous medicinal properties.

Table 4. Flavour compounds of spices

Spice	**Important flavor compounds**
Allspice	Eugenol, β-caryophyllene
Anise	(E)-anethole, methyl chavicol
Black pepper	Piperine, S-3-carene, β-caryophyllene
Cardamom	α-terpinyl acetate, 1-8-cineole, linalool

Turmeric	Turmerone, zingeberene, 1,8-cineole
Ginger	Gingerol, shogaol, neral, geranial
Mace	α -pinene, sabinene, 1-terpenin-4-ol
Nutmeg	Sabinine, α -pinene, myristicin
Cumin	Cuminaldehyde, p-l,3-mentha-dienal
Fennel	(E)-anethole, fenchone
Saffron	Safranol
Vanilla	Vanillin, p-OH-benzyl-methyl ether

The ideal climate and optimum production practices keep inherent qualities of Indian spices intact as result they are valued high in International market. It is essential to continue the tradition of conquering supremacy of Indian spices in the global market by combining modern tools and traditional technical knowhow's. There are a lot of unique flavour and quality we have in some of our spices such as Lakadong turmeric, Malabar pepper, *Bhut Jalokia* (Ghost Chilli) *etc*. which are under GI regime or being considered under GI regime.

Table 5. Estimated production target for spices in India (Qty. = tons)

Year/ Spices	Spices	Black [1] pepper	Cardamom (s)[2]	Ginger[3]	Turmeric[1]
2016-17	4810895	103733	67535	640934	897816
2021-22	5416858	115362	126330	819999	1037830
2026-27	6103366	128570	236580	1051128	1200210

Note: 1-With 80% import reduction; 2-With 0% import; 3-With 60% import reduction

Table 6. Value added products from some major spices

Spices	Product
Black pepper	Dehydrated green pepper, freeze-dried green pepper, frozen green pepper, white pepper, green pepper in brine, pepper oil, pepper oleoresin, ground pepper, organic pepper, sterile pepper, canned tender green pepper
Cardamom	Whole cardamom, cardamom seeds, cardamom tea, cardamom spray, cardamom soap, chutney, cardamom body oil, essence, cardamom sugar, seed essential oil
Ginger	Ginger oil, oleoresin, candy, preserves, vitaminized effervescent ginger powder, plain effervescent powder, starch from spent ginger, wine, beer, medicinal beverages, encapsulated ginger oil, dehydrated ginger
Turmeric	Curcuminoids, dehydrated turmeric powder, oil, oleoresin

Processing technologies should be modified/ upgraded to meet global standards and consumer preferences. Studies should be aimed at producing newer valued added products keeping in view the quality and consumer preferences to enhance our global trade. Government/agencies should promote farmers to cultivate varieties suited for specific processing/value addition with ensured buyback at a reasonably high price as there is high value and increased demand in the world market for these products.

GI Tag for NE spices

- Naga Chilli: In 2007, Guinness World Records certified that the ghost pepper was the world's hottest chilli pepper, 401.5 times hotter than Tabasco sauce; the ghost chilli is rated at more than 1 million Scoville heat units (SHUs). Classic Tabasco sauce ranges from 2,500 to 5,000.
- Mizo Chilli: Mizoram Birds Eye up to SHU 250,000. This chilli comes from eastern most part of India, bordering Burma. Just like it's sister chilli Bhut Jolokia from this region, this one packs punch of heat in it. While it's not as hot as Bhut Jolokia, nevertheless it's still very hot at more than 200,000 SHU. The flavour and heat is wonderful and very enjoyable too. This chilli will make the perfect Vindaloo.
- Karbi Anglong Ginger: Ginger fields in Karbi Anglong. The district produces the best organic ginger in the world. The average annual production of ginger in the district is 30,000 tonnes and it is grown by about 10,000 farmers. The ginger grown in Karbi Anglong has a low fibre content. Varieties such as Nadia and Aizol (possibly Thingpui or Thinglaidon), which yield high quantities of dry rhizome and oleoresin oil, are in great demand among domestic buyers and exporters.
- Lakadong Turmeric: A very high curcumin variety native to the village Lakadong in Jaintia hills of Meghalaya.

Road map for North East

The main strength of NE region is the Genetic Diversity:

Collect, conserve and commercialize should be the motto.

- All the germplasm endemic to NE region, along with their passport data, should be registered with NBPGR and accession number obtained.
- Register the unique germplasm with PPV&FRA as well as NBPGR to protect the ownership.
- It must be ensured that planting materials are locally produced and under the garb of HYVs, no material must be introduced in case of ginger and turmeric. There are very good local materials.
- There must be AICRP Centres for each state and must be fully staffed. It is sad that the entire NE has only one AICRP centre which is also voluntary.
- Identify wild germplasm for the useful genes and register them.
- When giving the materials on exchange, utmost care must be taken to see a proper LoA/MoU should be obtained even within NARS. Give the germplasm with accession number only.
- Make sure that these materials are not released elsewhere under different name.
- We must ensure with the cooperation of the Crop Sciences and Horticultural Sciences division that ownership of these materials are protected and when used in breeding programmes, it must be made available to ICAR Complex .
- There are many materials which go to make GI within an area and these must be registered as farmers' varieties or as Heirloom varieties.

The major developmental programmes envisaged under MIDH are

- Production and distribution of planting materials through development of model nurseries, tissue culture and seed infrastructure
- Rejuvenation/ replanting programmes

- Promoting INM/IPM strategies through development of forecasting techniques, plant health clinics, biocontrol labs *etc*.
- Technology dissemination through FLDs
- Popularizing post harvest management technologies

Conclusion and future thrust

The major thrusts in research programmes are oriented towards the following for increasing productivity of spices.

- Conservation of genetic resources and bar-coding of genotypes
- Raising the productivity of spices to the targeted levels using improved varieties with high yield, quality traits and disease/ pest resistance
- Increasing quality planting material production, crop management and replanting and rejuvenation of old gardens, good agricultural practices, INM and organic farming
- Increasing productivity of spices – to raise the production levels through IDM/ IPM
- Developing simple and cost effective tools and machines to offset labour shortage
- Chemo profiling and identification of new flavour compounds, bio active principles for patenting – to identify superior varieties with excellent flavour, identifying newer compounds for increasing the industrial use.
- New market oriented technologies for value addition, processing, product development – to increase the acceptability, demand and value of spices and new markets
- Development of data bases, prediction models, production strategies and market intelligence – use of GIS & Bioinformatics tools in spices cultivation, marketing and trade.

L5

Protected cultivation technologies for seed spice crops

Balraj Singh*& Ravindra Singh

ICAR-National Research Centre on Seed Spices,Tabiji-305206, Ajmer, Rajasthan
*drbsingh2000@yahoo.com

In the present era of science and technology, innovation and intervention of hi-tech farming technologies have shown high impact in agriculture and more specifically in horticultural crops. Focusing on horticultural crops, protected cultivation has proved to be a potent technology to manipulate the environmental conditions *in lieu* to the crop needs for proper growth and development. Advancement in protected cultivation has taken various forms as per the requirement. The commencement of the technology occurred with the establishment of glass houses in European countries to maintain high temperature for congenial growth of crops especially in the colder areas. Further reforms in the primitive models occurred in an innovative manner with the use of plastic and nets of various specifications, incorporated in numerous design from low to high cost structures. With the pace of time, technology of western world is finding enormous opportunity, especially in the hot lands of arid and semi-arid regions of India with modifications in basic models. In the last decade, tremendous area expansion occurred as a result of adopting protected cultivation technology specifically in vegetable cultivation. Looking into the technology which creates a barrier between external and internal (inside the protected structure) environments, it offers tremendous opportunities in seed spice crops also. The present paper is an insight into the scope of protected cultivation techniques in seed spice crops grown in the harsh climatic conditions of semi-arid and arid regions of the country. The issues regarding the use of other techniques like advanced nursery raising techniques, mulching, use of low cost protected cultivation technologies feasible and technically suitable for seed spice crops have also been discussed in this article. A brief and concise information has been furnished with respect to the techniques that have immense potential for application for seed spice crops cultivation in various parts of the country.

Plug tray seedling production technology for seed spices

In seed spices, the process of seed germination is very slow which may take several days to germinate after sowing. On the other hand, most of the seed spices are sown in dry fields by broadcasting followed by light surface irrigation. Low vigour and slow germination rate of these crops permit the weeds to proliferate faster in the initial 30 days, which creates tough plant-weed competition. Therefore, at initial stage of 50-60 days of sowing high labour input is required for weeding and hoeing. Moreover, for maintaining the soil moisture status the upper layer of sandy or sandy loam soil, a minimum of two to three irrigations are inevitable for enhancing germination and growth in the initial period of 30 days. This practice is common in western Indian parts of Rajasthan and Gujarat. In addition, some times when the farmers grows cluster bean during *kharif*, the crop is mostly harvested by the end of October to mid-November, whereas, the recommended optimum time for sowing of some seed spice crops like fennel, dill, ajwain, celery is by mid-September to end of September and therefore, it may not be possible for the farmer to take such crops in continuation to cluster bean. So, looking to the above narrated problems, an effective solution is to have an alternative technology rather than direct sowing of seeds after harvest of the *kharif* crop. Raising seedlings in nurseries provided solution to both the problems according to an experiment conducted at NRCSS, Ajmer. The seedlings of crops *viz*., fennel, dill, ajwain and celery were raised in soilless media (*i.e.,* cocopeat) in plastic beds and also in plug trays and 50-60 days old seedlings were directly transplanted in the fields. Both the systems of nursery raising showed 95-100% success rate in seedling establishment except in ajwain. Therefore, plug tray nursery raising technology was found suitable for all these crops *viz.,* fennel, dill, ajwain and celery, whereas, the plastic made and cocopeat filled bed technology was only suitable for fennel, dill and celery except, ajwain. The basic advantages of this technology are:

- We can save 50-60 days as the seedlings can be directly transplanted to the field *i.e.*, it gives an advantage of 50-60 days over traditional method.
- Lot of manpower can be saved in terms of weeding and hoeing at initial stage during which the crop-weed competition is high.
- Crops like cluster bean which is harvested by the end of October to mid-November is also suitable for the cropping system following fennel, dill, ajwain or celery crops in *rabi*, as the advantage of 50 to 60 days permits the *kharif* crop to mature in field and simultaneously take care of the successive crop to be transplanted in *rabi*.
- It also offers savings of resources in terms of nutrients and irrigation water which is applied in very high amount during early stage to protect young seedlings from high temperature and other environmental stresses.

Plug tray and plastic made soilless media filled beds for nursery raising in seed spices

Plastic mulching for seed spice cultivation

The technique is not new among the farmers and been used primarily in vegetables and fruit crops. As compared to the normal seed sown crop, as discussed above plug tray or plastic beds filled with cocopeat or traditional nursery raising practice offers a control over the crop-weed competition in the first phase *i.e.* for 30 days. To increase the crop potential, a complete control over the weed population from the very first day of crop establishment is highly essential. The technique of mulching is a fool-proof method to suppress the weed growth in the commercial crop sown area. Mulching layer also reduces the evaporation loss that occurs in open fields. Seed spices being grown in arid and semi-arid areas, *rabi* crop faces tremendous pressure of water management. The best combination of the mulching practice is with plug tray nursery raised seedling and drip irrigation for better resource management. Crops like celery are sown in the North West plains of Punjab where the cold period and water availability status are high compared to that of the areas lying in the western arid and semi-arid zones of Rajasthan and Gujarat. It has been observed by experimentation at NRCSS, Ajmer that, celery grows well when sown as transplanted crop under mulching with drip fertigation. The yield levels realized in the experiment shown tremendous potential of the technology in introducing the celery crop as a future seed spice for few tracts of western hot/ humid zone of the country. Similarly, this technology is also equally suitable for fennel, dill and ajwain in arid and semi-arid regions of the country.


Raised beds equipped with drip fertigation, transplanting and plastic mulching in seed spices

Temporary plastic walls for protection of seed spices against frost:

The main problem in the cultivation of seed spices is their susceptibility to frost damage. Due to frost, significant damage has been observed almost every year and during severe conditions total loss of crop has also been recorded. Frost occurs mostly during end of the year or at start of the year, when cold period is at its peak (mid-December to mid-January) and the crop is at its flowering stage. The umbel stalks are very tender and they hardly survive the cold breeze causing cold injury and death of the flower buds resulting in heavy yield losses. To manage this condition, a barrier is needed to block the cold wave over the crop canopy. Rather, low cost technologies like raising of plastic walls of 1-1.5 m height depending upon crop height from the field surface in the northern direction efficiently blocks the flow of cold waves and thus reduce the loss caused by frost significantly. A 150-200 μm thick transparent plastic sheet is suitable for creating artificial temporary walls in the field. These walls can be laid parallel if the field is large leaving a distance of 10-15 meters. A single wall in the north-south direction will reduce the chances of cold wave moment along the wall laid in north-west direction. The investment in raising the structure seems to be costly, but it is not, as the plastic is laid only for 20-25 days during peak winters and they are leaned along GI pipes or bamboo sticks which is durable and also can be reused for 3-4 years and in multiple activities like soil solarization *etc.* For crops like cumin and coriander, it can be advantageous, considering acreage of the crops and significant damage by frost is reported yearly in one or the other parts of the country. In addition, this can be a boon also in the vegetable crops, where the crops get supressed and damaged due to low temperature or frost in several northern plains of India.


Temporary plastic walls for protection of seed spice crops against frost

Transparent plastic covered walk-in-tunnel technology for seed spices cultivation

Transparent plastic covered temporary walk-in-tunnels is also suitable and effective for seed spice cultivation up to a limited extent. Plastic sheet of 150-200 µm thickness is laid in a semi-circle shape with ½ inch GI pipes fitted on the iron made plates fixed in the field at a distance of 2.5-3.0 m. The height of these walk-in-tunnels is seven feet at the center. This type of structure provides protection not only against frost but against unseasonal rains and hailstorms. Since plastic is used, the internal temperature rises and results in vernalization, as it induces early flowering compared to normal open field crop. A crop advancement of 20-25 days was observed for flowering as well as maturity. The investment cost is slightly higher but the inputs required are of long lasting nature. GI pipes can be used for 20-25 years and plastic is having a life span of 3-5 years depending upon the quality (if it is UV stabilized, it will last more). This technique is actually very low of cost and feasible for crops like coriander, ajwain and cumin, where heavy losses are reported due to abiotic factors. The additional advantage of these barriers are, it reduces the movement of insect pests and even wind-borne pathogens in the cropping zone, thus reducing the inputs required for insect and disease management.


Plastic covered walk-in-tunnels for protected cultivation of seed spices

Transparent plastic covered high-tunnel technology for seed spices cultivation

Transparent plastic covered temporary high-tunnels are also suitable and effective for seed spice cultivation limited to tall crops like fennel and dill. The height of the structure at the center from the ground is normally nine feet. This type of structure provides protection not only against frost but against unseasonal rains and hailstorms. It also helps in vernalization and other advantages are as those stated in transparent plastic covered walk-in-tunnel technology.

Plastic covered high tunnels for protected cultivation of seed spices

Combination of plastic covered high tunnels& plastic walls for protected cultivation of seed spices

Insect proof net covered walk-in-tunnel technology for seed spices cultivation

The technique of insect proof net covered temporary walk-in-tunnels are as same as above, the only difference is that the basic covering material used is UV stabilized nylon net of 40 mesh. This provides a more open type micro-climate compared to plastic covered as the temperature difference between the outer and inner structure is not much due to free air movement through the holes of the net mesh. The basic advantage of the technology is prevention against hailstorms and insects. The size of the mesh is smaller than the size of hailstorm and insects, which does permit the entry of these abiotic and biotic elements. It is an excellent technology for raising virus/insect free seedlings in vegetables. An intervention of this technique can limit the use of insecticides in these high value low volume crops facing tremendous pressure from western world of high pesticide toxicity in Indian produce. Crop like cumin, when it is to be grown in organic system, efficient pest management strategy is by implementing insect proof net covered walk-in-tunnel completely closed from all sides for complete restriction of aphids and other insects.

Shade net covered walk-in-tunnels technology for off-season cultivation of green leafy seed spices during peak summer season

The present technology is a very simple approach to make the crops to be raised during off-season for green leafy purpose. Seed spices, specifically coriander and fenugreek are grown during *rabi*, are also having importance for their green leaves. Coriander leaves are an integral part of Indian cooking system and are needed round the year for adding taste to the cuisines. Leaves being the most perishable part have a limitation of transportion from one corner to other. During the peak summer months (May to July) the availability of coriander leaves is highly influenced nd there is a sharp rise in the rates per kg leaves sold during summer. The present technology of shade net covered walk-in-tunnel is an intervention found to be most suitable for the farmers of arid and semi-arid regions of the country where the summer temperature goes beyond 45°C coupled with hot waves. Mostly 50-60% shading intensity shade net covered walk-in-tunnel can be coupled with low pressure drip irrigation system to obtain good quality coriander leaves. During summer months, problem of early bolting occur in open field, even genotypic differences are noticed for bolting under open and shade net conditions. Presently, large areas are sown by temperate type coriander by farmers for leaves. However, this temperate type attains good vegetative growth providing huge biomass of leaves for sale, but does not possess the aroma as the temperature required for metabolism of flavouring biochemical constituents is not as per the temperate conditions in plains. These temperate type late bolters due to high leaf yield have gained popularity among farmers. But the other side of the coin the consumers are not happy, as the leaves of temperate types does possess the desired aroma for adding the flavour we want. A study was conducted at NRCSS, Ajmer to screen the genotypes for adaptability under shade net walk in tunnels for leaf yield and aromatic quality. Huge variation was observed for both bolting time and aromatic quality. Compared to the temperate type of coriander Indian genotypes had high aroma. Variety ACr-1 which is a dual type bolted in 40-42 days during peak summer months, whereas, one genotype Ajmer Green Coriander-1 bolted in 52-55 days and had the high aroma in leaves. It was also found to be free from powdery mildew which occurs in the humid micro-microclimate of shade net equipped with drip. The said genotype AGC-1 is under pipeline for release in the near future for off-season cultivation. The intervention of low pressure drip in the technology is very much feasible for the arid and semi-arid area as during peak summer months water is the most limiting factor, a plastic tank of 1000 litres is sufficient to irrigate an area of 1000 sq. m. The technology is a boom for seed spice growers and other farmers to earn more from selling coriander leaves in peak summer months at high price. Study conducted on fenugreek had shown possibilities of growing fenugreek for leaves during summer months also.

Shade net covered walk in tunnels for off season cultivation of coriander and fenugreek during peak summer months

Transparent plastic covered high tunnels for drying kasuri methi during winter season

Rajasthan, the land of seed spices is having a typical climatic condition for growing high quality kasuri methi in the Nagaur district. The soil type, above surface climate and water quality in combination with the local genotype adds the value to the crop. Indian kasuri methi is exported around the world. In Mundwa region of the district, the concentration of kasuri methi growers is very high and interaction with the farmers revealed the problem in drying in open fields. The crop is harvested multiple times during the season and a drying cycle goes on simultaneously in *rabi*. Hence, winter rains, frost, low temperature stress and bright sunshine during day time deteriorate the desired quality with respect to colour and aroma. Even biotic damage is also observed in humid conditions. To overcome the problem, NRCSS, Ajmer demonstrated a very simple and feasible technique of using high tunnels covered with transparent plastic during the winter season. This not only saved the crop from rains, frost and other damage but also reduced the drying period by 2 days compared to 4-5 days in open fields. The tunnel dried product obtained 20-25% premium price compared to traditional dried kasuri methi during the current season as reported by the farmers of the area. High tunnels also allowed movement of tractor inside the structure thus increasing the working efficiency under the structure. Crops like fennel can be raised in high tunnels to protect it from climatic vagaries.

Conclusion and future scope

The overall view of the aspect to introduce protected system of cultivation in seed spices seems to be potential enough in the coming days. The above mentioned technologies have higher scope in hi-tech cultivation of seed spices. The scenario of climate change may force to shift to these protected cultivation practices in future. The future of seed spices is of resource efficient cultivation practices, intervention of good agricultural practices (GAP) and precision farming to add more value to the produce. Still there are many aspects to be studied, the crop behaviour, genotype response, protected cultivation models with respect to production and protection system, scope of protected cultivation in organic farming *etc*.. All these aspects are under consideration and research is going on. In the future, the cultivation of these crops may take up a modulated shape of hi-tech farming as being the most important export commodity of the resource deprived semi-arid and arid regions of the country.

Session I

Genetic Resources, Crop Improvement & Biotechnology

Lead Lectures

L6

Designing a plant for seed spices

E V Divakara Sastry

Division of Plant Breeding & Genetics
Rajasthan Agricultural Research Institute, Durgapura-302018, Jaipur, Rajasthan
evdsastry@gmail.com

According to an estimate the global demand for food is going to be doubled by 2050 because of the increase in population, consumption and because of the quality of life (Kastner *et al.* 2012; Tillman *et al.* 2011). The demand is going to be even more in spices, as spices add flavour and quality to the food. All this demand is to be met from the existing land resources only, with no increase in arable land, avoiding environmental degradation, maintaining the ecosystems as they are and also preventing biodiversity (Cassman 1999; Tillman *et al.* 2011). Spices will get even less land, as the demand for land by the major food crops particularly cereals over weigh against the spices, this is particularly true for seed spices which as such are grown on less favoured lands. Even in the major crops, which had the greater attention in terms of breeding efforts and improvement, stagnation in crop yield growth rates in various regions around the world have become common place such as in rice (Lobel & Gourdji 2012; Ray *et al.* 2012), wheat (Ray *et al.* 2012) and partly attributed to changes in agronomic management and climatic conditions (Ray *et al.* 2012) as well as due to increasing water scarcities and nutrient status of the soil (Carbewrry *et al.* 2013). All this prompts to rethink on how to breed better yielding genotypes for sustained production/productivity in a myriad of forces which limit the crop production. With information on the genetics becoming available and with the molecular genetics playing a greater role in crop improvement. It is imperative that an ideal plant type is designed to assist the breeder to breed high yielding and adaptive genotypes for various cultivation requirements.

I wish to quote few lines from (Donald 1968) "When a new variety is produced in this way, the plant breeder may not know why it yields better than its predecessors. A wheat breeder who recently produced a high yielding variety of wheat, was asked what attributes gave it such capacity for yield; he replied, "I do not know... but I will list the characteristics of the variety and it is for the physiologist to judge whether these may be the reasons for the high yield." Many cereal breeders selecting for yield give a like reply, or state that the new variety has "better adaptation" to the environment". Unfortunately these lines appear to be true still and particularly in seed spices.Breeding efforts can be categorized into two groups- "defect elimination" which basically mean removing any kind of defects in the plants to make them more productive, like breeding for disease resistance and the second group "selection for yield", which basically mean breeding cultivars which have higher yield than their competitors (Donald 1968). In seed spices the "defect elimination" is still in infancy while almost all the efforts are directed towards "selection for yield". This is time we think of modifying our efforts.

The term ideotype as introduced by (Donald 1968) basically refers to a biological model which is expected to perform or behave in a predictable manner within a defined environment. In other words, it refers to a model plant or ideal plant type that the breeder will make efforts to achieve. Naturally this will depend on different components inherent to the plant. All the plant types that we see today are specific ideotype that nature has modelled for different ecological niches. So that all the species are adjusted in the limited space and there is less competition for space and resources.However, when it comes to cultivated crops, the needs become different, hence essentially, it becomes a different ideotype.

Three types of ideotypes can be observed in crops.

- Isolation ideotype- it is the model plant type that performs best when the plants are space planted. In seed spices, although space planting is recommended, yet in actual cultivation, broadcasting is still the common method of sowing.
- Competition ideotype- this ideotype performs well in genetically heterogeneous populations. In case of cereals, this ideotype is tall, leafy, free tillering plant that is able to shade its less aggressive neighbours. In seed spices, this is the type one would prefer. The characters that are expected to be present should propagate competitive ability in the plants.
- Crop ideotype- this ideotype performs best at commercial crop densities because it is a poor competitor. This type of ideotype is better suited for good management conditions. In cereals, this type of ideotype advocates a plant which is erect, sparsely tillered with errect leaves as such plants can be packed densely.

Besides these, based on the requirements, several other types of ideotypes are also identified such as-

- Market ideotype- includes traits like seed colour, seed size, cooking and baking quality *etc.* in other words a model which is based on all such characters which influence the marketability of a product. Since spices are grown and used for their quality which again is influenced by market driven forces, model for the spices may be based on this type of ideotype.
- Climatic ideotype- includes traits of importance in climatic adaptation such as heat and cold resistance, maturity duration, drought resistance *etc.*with the changing climatic scenario, inclusion of traits which give adaptation to the climatic changes is becoming of paramount importance to the breeders and already a large debate on designing crop ideotype particularly in cereals is going on (Rotter *et al.* 2014).
- Edaphic ideotype- the ideotype includes salinity tolerance, mineral toxicity/ deficiency tolerance *etc*. with climatechange, the changes in edaphic factors affecting the plant growth are also on the raise, hence the requirement of developing anideotype suitable for the edaphic factors.

Development of ideotype is a conceptual one and requires inputs from all the stake holders. A good ideotype is based on interdisciplinary approach and is a continuously evolving process with new inputs integrating into the ideotype concept. Donald (1968) proposed the ideotype approach to plant breeding in contrast to the empirical breeding approach of defect elimination and selection for yield per se. He defined ‘‘crop ideotype’’ as an idealized plant type with a specific combination of characteristics favourable for photosynthesis, growth and grain production based on knowledge of plant and crop physiology and morphology. Thus according to him, an ideotype is a biological model that is expected to perform or behave in a predictable manner within a defined environment, emphasizing on the importance of understanding both the genotype performance and the environments to define the relevance of a specific combination of traits. He argued that it would be more efficient to define a plant type that was theoretically efficient and then breed for this (Hamblin 1993). Recently (Matre *et al.* 2015) extended this definition suggesting that the ideotype is a combination of different types of traits (morphological, physiological) or its genetic basis that confer enhanced performance for a particular (i) biophysical environment, (ii) specific cropping system and (iii) end use of the crop. Crop simulation models have been applied in various ways to support plant breeding, e.g. to design crop ideotypes for different environments aimed at minimizing resource use per unitof dry matter produced and to increase crop yield potential (Aggarwal *et al.* 1997; Dingkuhn *et al.* 1991). Particularlypromising has been the application of crop simulation to estimateyield potential in crop ideotypes designed for projected future climates. For example, Semenov *et al.* (2014) appliedwheat simulation model Sirius across Europe to optimizewheat ideotypes for future climate scenarios, whereby a wheatideotype was defined as a set of selected cultivar parametersrelated to photosynthesis, phenology, crop canopy characteristics and water relations. By changing parameters fromgiven value ranges and optimizing them for yield in responseto changing climate or environmental conditions, ideotypes were defined that showed best yield performance under well-definedfuture conditions.

Coriander

Coriander is used both as herb (for leaves) as well as for seed. The seeds as well as plant parts contain essential oil which actually impart the typical flavour to the coriander. The chemical composition of the essential oil is described by (Parthsarathy & John Zachariah 2008). The general cultivation method includes sowing of seeds by broadcasting either in raised beds or in flat beds and harvesting the leaves either by cutting at an interval of 25 to 30 days (generally two cuttings are taken) or by uprooting the plants at 25-30 days when sown for leaves and broad casting or line sowing when the crop is intended for seeds. A good description about the cultivation method is given by Sastry *et al.* (2009). A good account of the plant type is given by Diederichsen (1996) and Sastry *et al.* (2011). Distinct changes are seen in plant type during the life cycle of the plant. Based on the differences in the plant shape, three types are recognized- prostrate (spreading), semi erect and erect (Sastry *et al.* 2011). The spreading types are better suited for leaf purposes as their biomass is more and they rapidly grow. But when one is interested in seed types, the erect plant is found to be better suited. For the development of the ideotype, it is essential to understand the morphological characters vis-à-vis their relation with the final character the seed yield. Unfortunately as of now the genetics of morphological traits that affect the seed yield in coriander is still not know although, correlation and path analysis have thrown some light (Arif *et al.* 2014; Dyulgerov & Dyulgerov 2013; Meena *et al.* 2014). Most of the morphological traits show high genetic diversity and are positively correlated with seed yield. Most important, there is positive correlation of seed yield with the days to flowering and maturity (Pandey 2013) or the correlations are very weak with high positive direct effect (Idhol *et al.* 2011). This needs some relook. In order to further understand, a detailed study of the different types of flowering characters and morphological traits as well as seed yield was studied with a view to understand the flowering behaviour and morphological traits which impact yield (Pandey 2013). The multivariate analysis based on principal component analysis of all the genotypes indicated wide variation among the genotypes (Fig. 1). Further analysis of the characters has indicated two distinct groups of characters- those related to flowering and morphological characters (Fig. 2). This indicates importance of the flowering duration in the seed yield. Further, when the genotypes were categorized based on the seed yield, the top yielding genotypes were in general long duration varieties, while the low yielding genotypes were generally early to flower and to mature. Further an initial study on the number of leaf cuttings vs seed yield of selected genotypes at S K N Agriculture University has shown that seed yield of the genotypes which have given two cuttings of leaves was generally lower. These findings support the view that the genotypes for leaf yield should be distinct from the types which are bred specifically for the seed yield. The erect types are better suited for the seed yield. Observations from the correlations study indicate that it is ideal to have genotypes which start flowering earlier and also have long grain filling period. However, with the climate change as it is happening, towards the maturity, coriander is exposed to sudden rises in the temperatures in North India. Under such conditions, having long duration plant types will be detrimental. As such a positive correlation between seed yield and flowering is seen. So in order to breed climate resilient genotypes, this positive correlation will have to be broken. Mutation breeding may become the method we desire. These are preliminary observations and knowledge of physiological parameters will be needed before a logical ideotype is designed.

Fennel

Fennel is long duration crop with indeterminate flowering behaviour. The plant is generally tall. As of now very little information is available which may be used for designing an ideotype. As such the plant types can be classified into short and tall types. The fennel is cultivated by two methods- direct sowing and transplanted. The transplanted types require long duration (>10 months) while the direct sowing is raised as *rabi* crop required around 6 ½ months. The heights of the plants reach 2 m. for good quality product, multiple pickings are practiced. This is particularly required when the harvesting is done for green fennel which has good flavour and fetches more price. Again, a positive correlation between major morphological traits and seed yield is reported in fennel (Yadav *et al.* 2013) while very low non-significant correlation has been reported between days to flowering and seed yield (Singh 2003). Hence, genotypes with late flowering habitat are high yielding. Therefore the ideotype for high yielding varieties should incorporate shorter height, start flowering earlier and as far as possible should be synchronous in maturity. Such genotypes are expected to yield high in short duration. Even the foliage is profuse and drooping. Fennel is intercropped with several other crops. Therefore compact plant type is a preferred ideotype for fennel when used in intercropping.As of now genotypes which are shorter and showing synchrony in maturity are not found in fennel. Once again mutation breeding may come to rescue to develop unique plant type. At ICAR-NRCSS, Ajmer, mutants which are very short have been identified although the stability of their performance is yet to be studied.

Fenugreek

Fenugreek plant has a slender stem owing to which the plants prostrate. Because of the prostrate habit, plants get entangled and become vulnerable to soil born fungi. Moreover, the pods appear along the stem because of which non synchronous maturity is observed. This also makes machine harvesting difficult and the realized yields are low. Fortunately we have determinate plant type (UM 305) available. This genotype is short and the pods point upwards which makes high density sowings possible. This plant type may be used as a model ideotype to breed high yielding varieties in fenugreek. Fenugreek is plagued by powdery mildew and downy mildew and are becoming serious concern.

Cumin

The plants of cumin are slender and short with near synchronous flowering and maturity making the plant type an ideal plant. The biggest challenge in cumin is its susceptibility to biotic stresses namely wilt and blight. As of now no resistance source is available against both the diseases. Hence intense search for resistant source is required. Search for somaclonal variants using *in vitro* techniques have been done (Jakhar 2003) but with limited success.

Prologue

In seed spices, in order to develop ideotype basic genetic information is still not available. Even the physiological and biochemical traits which affect the yield and the quality of spices *i.e.* essential contents in case of coriander, fennel and cumin and diosgenin content in fenugreek are still not worked out. With the available information, breeding for synchrony in flowering and maturity, errect type with higher sink size in relation to source is needed so that optimum yields are obtained under irrigated conditions. With the availability of information on the genetics of major morphological traits and the effect of changing climate, we may develop ideotype for different situation enumerated at the beginning of this manuscript. With the availability of information one may develop ideotype for a given situation as proposed (Rotter 2015) even through simulation model.

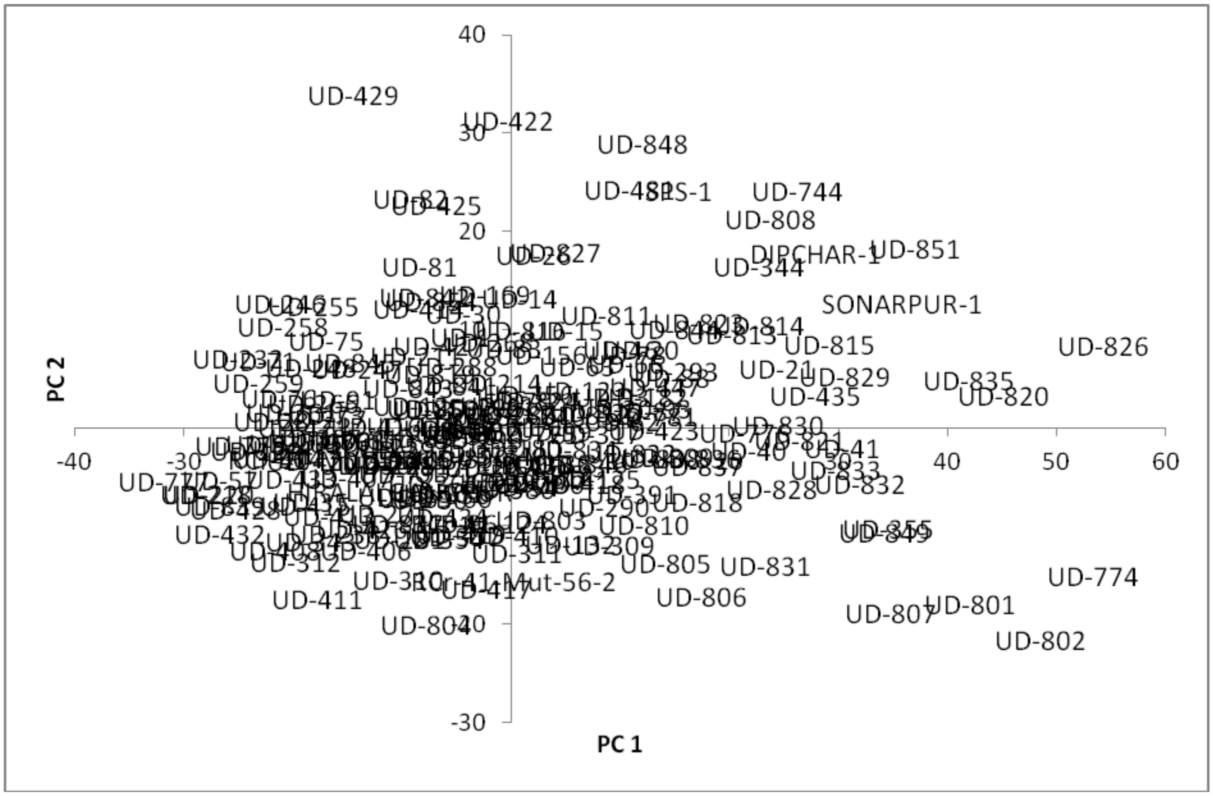


Fig. 1. Scatter diagramme for the first two principal components for the genotypes evaluated. Based on (Pandey 2013)

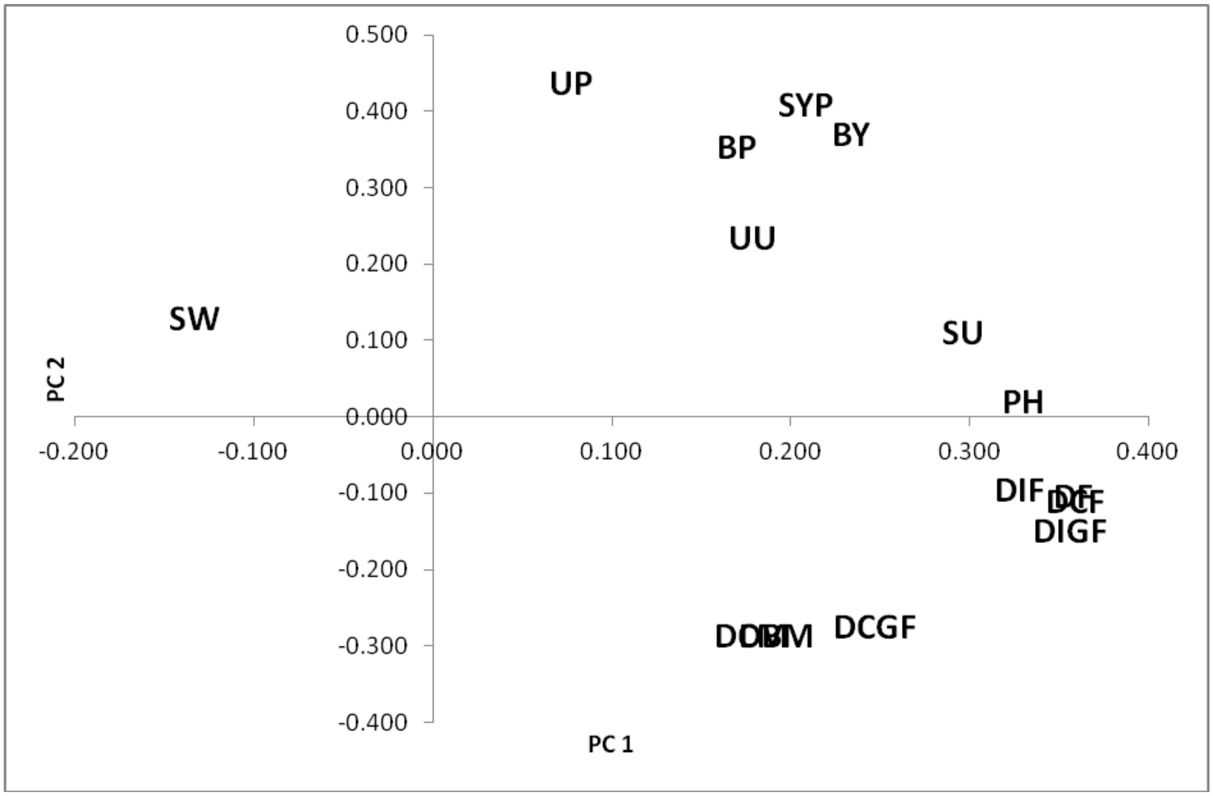


Fig. 2. Scatter diagramme for the first two principal components for the characters evaluated [based on (Pandey 2013)]. SW- seed weight, UP- umbels per plant, BP-Primary branches per plant, SYP- seed yield per plant, BY-biological yield, UU- umbellets per umbel, SU- seeds per umbel, PH- plant height, DIF- days to initiation of flowering, DCF- days to completion of flowering, DCGF- days to complete grain formation, DF- days to 50% flowering, DCM- Days to complete maturity.

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Oral Presentations

O1

Varietal diversity in nutmeg

N Mini Raj*, H C Vikram & Priyanka S Chandran

Department of Plantation Crops & Spices,
College of Horticulture, KAU, Thrissur-680656, Kerala
*n.miniraj@kau.in

Nutmeg (*Myristica fragrans* Houtt.) belonging to family Myristicaceae is unique among other spice crops as the donor of two distinct spices, nutmeg and mace. Area and production of this perennial tree spice in India is steadily increasing over the past few years. The state of Kerala holds number one position with respect to the area and production of nutmeg. Globally, Indonesia and Graneda dominate production and exports. During 2014-15, India produced about 13,410 tonnes of nutmeg and mace from an area of 20,210 ha and exported 4475 tonnes worth Rs. 26,798 lakhs.

Nutmeg is usually a dioecious tree though other sex forms occur sporadically. It is a cross pollinated crop. Viswashree is an improved variety of nutmeg developed at ICAR-Indian Institute of Spices Research, Kozhikode. Keralasree, is another nutmeg variety developed by ICAR-IISR in a participatory breeding mode. Three varieties have been released from Konkan Krishi Vidyapeeth, Dapoli. Konkan Sugandha is the only hermaphrodite variety released in nutmeg so for. Konkan Swad and Konkan Shrimanti are the other two varieties released by Konkan Krishi Vidyapeeth, Dapoli. One of the major constraints in nutmeg cultivation is the lack of improved varieties. Very little work has been done in the crop improvement of nutmeg. At present, there are many elite types identified and popularized by progressive farmers in Kerala which excel the released varieties in yield as well as quality.

A recent study at Kerala Agricultural University evaluated 41 accessions of nutmeg collected from diverse locations of Kerala for quantum of variability available in fruit characters. High PCV and GCV were observed for the characters, fruit weight, mace weight (both fresh and dry), mace volume, dry nut weight, kernel weight, fruit volume and number of fruits per tree. Heritability was high for all the characters except shell thickness. High GCV coupled with high heritability indicated the scope for selection based on these characters. Genetic gain was highest for number of fruits per tree (144.3%) followed by mace characters *viz*., fresh weight, dry weight and volume of mace. Hence, selection programme based on number of fruits per tree can bring about nearly 144% improvement in the base population.

Research on nutmeg need to be strengthened. Priority should be to identify monoecious as well as bisexual types, to develop high yielding varieties with bold nut, thick and entire mace, to evolve high quality varieties for myristicin, elemicin, sabinine, safrole *etc*., to develop varieties suitable for high density plantingand to develop varieties tolerant to biotic (leaf fall, anthracnose, die back, white thread blight, horse hair blight, gummosis and root rot) and abiotic stress (drought). Systematic hybridization programme is yet to gain momentum in this tree spice. Tremendous variability available for the quantitative as well as qualitative characters of economic importance could be combined.

HS Mehta Memorial Award Presentations

H1

Developing minimal descriptor for nutmeg (*Myristica fragrans* Houtt.) and characterization of germplasm

H C Vikram*, N Mini Raj, Deepu Mathew[1] & EV Nybe[2]

Department of Plantation Crops & Spices,
College of Horticulture, Vellanikkara, Thrissur-680656, Kerala
[1]Centre for Plant Biotechnology & Molecular Biology,
College of Horticulture, Vellanikkara, Thrissur-680656, Kerala
[2]Kerala Agriculture University, Thrissur-680656, Kerala
*vikram.hc@gmail.com

A study was undertaken at Kerala Agricultural University, Thrissur during 2012-2015 to develop a minimal descriptor for nutmeg, utilizing a core germplasm collection maintained at Central Kerala in the Chalakkudy river basin. Fifty selected nutmeg accessions including forty two females, four monoecious and four males, were subjected to detailed morphological characterization for two consecutive years. Fifty one qualitative and thirty eight quantitative parameters were recorded at various phenophases and a descriptor and descriptor states were developed. Accessions were categorized based on the expression of character by giving score in a 0 to 9 scale. Yield contributing traits such as, tree height, canopy shape, canopy spread, branching pattern, season of flowering, periodicity of flowering, number of flowers as well as fruits per cluster, nature and density of fruit bearing, number of fruits per m^2, bearing season, fruit set percentage and number of fruits per tree showed tremendous variability in the germplasm under study. Fruit, nut and mace characters were also categorized in the same pattern. Similarity coefficient values among the accessions for the qualitative characters ranged from 0.49 to 0.86 per cent. Accessions fell into eleven clusters at 66 per cent similarity. Based on Mahalanobis D^2 analysis for quantitative characters, the accessions fell into ten clusters. Homology in the distribution of accessions into qualitative and quantitative clusters indicated that, fifty percent of the qualitative cluster accessions were equally distributed into quantitative clusters and the remaining exhibited scattered distribution.

H2

Characterization and evaluation of *Nigella sativa* L. genotypes for growth, yield and quality

Y Diwakar*, R K Kakani, S SRathore, C B Harisha, H Asangi& R K Solanki

ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer-305206, Rajasthan
*diwakar.nrcss@yahoo.com

Nigella sativa L. is an annual herbaceous medicinally important seed spice of the family *Ranunculaceae*. Owing to the immense therapeutic dominance possessed by *N. sativa*, the plant is greatly renowned and widely desired as a natural source of drug besides its aromatic and flavouring characteristics. Considering the pharmaceutical novelty, profitability and demand, twenty four genotypes (AN-1 to AN-24) collected from diverse sources were characterized and evaluated for various growth, yield and

quality traits at ICAR-NRCSS, Tabiji, Ajmer, Rajasthan during *rabi* 2014-15. Among the genotypes, maximum number of primary branches (7.6) and secondary branches (17.2) were recorded in AN-10 while, minimum was recorded in AN-17. In the parameter days to 50 per cent flowering, early flowering (64 DAS) was observed in AN-16 while, late flowering (77 DAS) was observed in AN-15. Among the parameters contributing to the yield, maximum number of siliqua per plant (70.8) was recorded in AN-24 and minimum (25) in AN-13. AN-19 recorded maximum number of seeds per siliqua (93.92) and maximum siliqua size of 3.36 cm, while minimum (2.74 cm) was recorded in AN-1. Maximum seed yield of 12.83 g per plant and total oil yield of 26.99% was recorded in AN-24. In the parameters weight of 1000 seeds and seed size, maximum weight (3.03 g) and size (0.45 cm) were recorded in AN-4 while, minimum of 1.93 g and 0.1 cm were recorded in AN-9. It is deduced from the study that, the genotypes differed significantly for most of the parameters and offers good scope of selecting parents for future crop improvement programmes.

Poster Presentations

P1

Screening of some black pepper genotypes for water stress tolerance

P M Ajith* & V P Neema

Pepper Research Station, Panniyur, Kannur-670142, Kerala
*ajith.pm@kau.in

Twenty seven genotypes of black pepper (*Piper nigrum*) maintained at the field germplasm conservatory were subjected to screening for water stress tolerance using the parameters leaf dry matter content (LDMC), specific leaf area (SLA) and twig dry matter content (TDMC). LDMC range of 200 mg/g to 250 mg/g was found to be ideal for identifying water stress tolerant genotypes of black pepper. Among the accessions evaluated, thirteen genotypes fell in the range of LDMC value 200 to 250 mg/g and the genotypes P 3 and Acc. 57 showed LDMC <210 mg/g. Thirteen genotypes showed an SLA value of less than 15 mm^2/mg which was found to be the maximum limit for water stress tolerant genotypes. Acc. 53, Acc. 57 and Panchami showed TDMC less than 215 mg/g. LDMC and TDMC were found to be the good tools for screening of black pepper genotypes for water stress tolerance.

P2

Evaluation of pepper varieties in the coastal plains of Tamil Nadu

V Krishnamoorthy

Department of Horticulture,
Agricultural College & Research Institute, TNAU, Madurai-625014, Tamil Nadu
krishorttnau@gmail.com

The study was conducted at Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Pudukkottai, Tamil Nadu with black pepper varieties *viz*., Karimunda, Panniyur 1, Panniyur 2, Panniyur 3 with four shade-cum-support trees namely, *Delonix elata*, *Thespesia populnea, Commiphora caudata* and *Gliricidia maculata* under permanent shade of coconut trees (20 years old). The trial was taken up in the farmer's field during January 2005. The results revealed that, Panniyur 1 recorded higher number of primary branches (45/vine), secondary branches (3/primary branches), bearing shoots (130/plant), internodal length (8 cm), leaf length (15 cm), leaf breadth (7.5 cm), number of leaves (1215/plant), petiole length (2.2 cm), number of spikes (405/plant), number of berries (80/spike), spike length (12 cm) and dry yield (1.1 kg/plant, 330 kg/acre). Among the other varieties, Karimunda performed better in terms of growth and yield and gave additional income from the coconut garden (Rs. 198000/acre/year). Among the four shade-cum-support trees evaluated, *D. elata* was found to be the best for coastal region, as there was no occurrence of pests and the growth rate, regeneration after lopping were desirable compared to other trees. It is concluded that, to realize higher yield in coastal plains, the pepper variety, Panniyur 1 can be grown on the shade-cum-support tree, *D. elata*.

P3

Wide hybridization and embryo rescue technique; a promising approach to overcome the barriers for gene transfer in spice crop improvement

K Prasanth*, Anil Sebastian[1]& Lokesh Bora[2]

Division of Vegetable Crops,
ICAR-Indian Institute of Horticultural Research, Bengaluru-560089, Karnataka
[1]Department of Seed Science & Technology,
[2]Department of Fruit Crops, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*kpras.agri@gmail.com

Wide or distant hybridization, a mating between individuals of different species or genera, provides a way to combine divergent genomes into one nucleus. Wide hybridization breaks the species barrier for gene transfer and thus makes it possible to transfer the genome of one species to another, which results in changes in genotypes and phenotypes of the progenies. In black pepper, an attempt to bring resistance genes from wild relatives to cultivated types, interspecific hybrids between *P. nigrum* x *P. attenuatum* and *P. nigrum* x *P. barberi* was successfully developed. *Phytophthora* foot rot (*Phytophthora capsici*) resistance was transferred from exotic wild *P. colubrinum,* a diploid species to *P. nigrum,* the cultivated tetraploid, resulted in triploid hybrid progeny P5PC 1. In cardamom, inter-generic crosses were made using *Amomum subulatum*, *Alpinia neutans*, *Hedychium flavescens* and *Hedychium coronarium* as male parents. Cross with *A. neutans* set a few fruits and in other cases no fruit formation was noticed. Further studies in this line have identified that, compatibility barriers prevented the formation of fruits in these cross combination. Sexual barriers preventing interspecific hybridization have been distinguished into pre and post-fertilization barriers. Embryo rescue is normally used in distant hybridization to overcome post-zygotic incompatibility. Embryo rescue technique helps in making the interspecific crosses successful when there is post-fertilization dormancy between the embryo and endosperm. Embryo rescue has been applied widely in many crop species including spices for overcoming incompatibility during wide hybridization.

P4

Farmers' varieties in black pepper (*Piper nigrum* L.) and small cardamom (*Elettaria cardamomum* Maton) short listed for PPV & FRA registration

K Hemesh, Johnson K George*, K V Saji, B Sasikumar, D Prasath& K Pradip Kumar[1]

Division of Crop Improvement & Biotechnology,
ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
[1]Indian Cardamom Research Institute, Spices Board, Myladumpara, Idukki-685554, Kerala
*kokkatjohn@spices.res.in

The protection of plant varieties and farmers' right act came into existence during 2001 with the aim of providing and establishing an effective system for protecting plant varieties, the right of farmers and plant breeders to encourage the development of new plant varieties. The PPV&FR act recognizes the right of farmers with respect to their contribution in conserving, improving and making available

farmers varieties and local landraces in their custody as plant genetic resources for the development of new plant varieties. Notifications for registration of major spices like black pepper and small cardamom were done by PPV&FRA during April 2010. Distinctiveness, uniformity and stability test (DUS test) procedures were followed for registration of varieties. Black pepper and small cardamom being perennial crops, on-site DUS test procedures are accepted for characterization, which is a mandatory requirement for registration. ICAR-IISR is a nodal centre for DUS testing in spices *viz*., black pepper, small cardamom, ginger and turmeric. A number of farmer's varieties in black pepper and small cardamom are being considered for registration by PPV&FRA, which include black pepper varieties *viz*., Pepper Thekkan, Kumbuckal Selection and Agali Pepper and small cardamom varieties *viz*., Elarajan, Wonder cardamom, Ela (white flower cardamom), Thiruthali, Panikulangara green bold no.1 & Panikulangara green bold no.2. Most of these are accepted by farmers and are getting wide popularity among the farming community for their unique characteristics and field performance.

P5

Role of biotechnology in *In vitro* conservation of spices germplasm

Anju Jain* & R P Yadav

Tissue Culture & Cryopreservation Unit,
ICAR-National Bureau of Plant Genetic Resources, New Delhi-110012
*anju_oswal@rediffmail.com

India is the traditional producer, consumer and exporter of spices and stands first in the production of most of the spices. A large number of important spice crops are sterile or do not easily produce seeds or highly heterozygous and hence to conserve elite genotypes, clonal propagation is preferred. Biotechnological approaches have made it easy to collect and conserve plant genetic resources in the form of traditional varieties, modern cultivars, wild relatives and other wild species, especially of those species which are difficult to conserve through seeds. Tissue culture techniques have been adopted to conserve germplasm of wild, endangered, threatened species as well as selected elite varieties, facilitating safer distribution and preservation of the genetic integrity in a relatively small space; under a secured pest and pathogen-free state. Looking upon the importance and genetic diversity of vegetatively propagated spices comprising of ginger, turmeric, vanilla, *Humulus*, *Piper*, *Simmondsia* and *Elettaria*, a total of 240 accessions are being maintained under medium-term conservation in the *in vitro* genebank at ICAR-NBPGR, New Delhi. After establishment of protocols for short to medium-term conservation of spice germplasm at NBPGR, attempts are being made to establish an effective cryopreservation protocol for long-term preservation using vitrification technique.

P6

Performance evaluation of elite genotypes of cardamom (*Ellettaria cardamomum* Maton) in Karnataka

S Sreekrishna Bhat, N Duhita, K A Saju & K Pradip Kumar*

Indian Cardamom Research Institute, Regional Station,
Spices Board, Sakleshpur-573134, Hassan, Karnataka
*pradipknair@rediffmail.com

A trail was conducted at Indian Cardamom Research Institute, Regional Station, Sakleshpur, Karnataka under All India Co-ordinated Research Project on Spices with an objective to assess the performance of elite genotypes of cardamom. The experiment was initiated during 2009 with fourteen genotypes and two checks, laid out in RBD with three replications. Number of tillers was significantly higher in IC 34987 (29.5), followed by SKP 164 (29). Plant height was significantly higher in SKP 164 (264.8 cm), followed by IC 547185 (264 cm). The bearing tillers per plant were significantly higher in IC 34987 and SKP 164 (15.9), followed by IC 349651 (15.2). Significantly higher number of panicles was observed in SKP 164 (29.7), followed by IC 34987 (29.1). Number of racemes per panicles were significantly higher in IC 34987 (22.4), followed by SKP 164 (21.7).Significantly higher number of capsules per raceme were recorded in MCC 346 (4.1), followed by MCC 260 (3.9).The dry yield was significantly higher in IC 34987 (910.8 kg ha^{-1}), followed by SKP 164 (904.2 kg ha^{-1}). Maximum bold capsules (8 mm & above) were recorded in MCC 346 (51.9%), followed by SKP 164 (47.5%). Oil content was maximum in SKP 164 (7.6%), followed by CL 691 (6.9%). Least infestation of capsule borer was observed in CL 726 (1.7%), followed by MCC 260 (2%). Thrips infestation was least in CL 691 (0.95%), followed by IC 547167 (1.2%). Incidence of capsule/panicle andrhizome rot was least in IC 547185 (1.3%) and ICRI 3 (4.5%), respectively.

P7

Chemical composition and physical characteristics of different varieties of small cardamom

John Jo Varghese, Xavier Reivax*[1] & Manoj Oommen

Indian Cardamom Research Institute, Spices Board, Myladumpara, Idukki-685553, Kerala
[1]Peermade Development Society, Peermade, Idukki-685531, Kerala
*xavier202reivax@gmail.com

An experiement was conducted at Indian Cardamom Research Institute, Spices Board, Myladumpara to evaluate the volatile oil, essential oil composition and physical characteristics of eight different varieties of cardamom *viz*., Njallani, Thiruthali, Panikulangara 1, ICRI 2, ICRI 5, ICRI 6, ICRI 7 and Elarajan. The volatile oil content was found to be highest in Njallani (8.2%), followed by ICRI 2 (8%). The maximum content of aroma and flavour imparting compounds *viz*., 1,8-cineole and α-terpinyl acetate were recorded in Njallani (29% and 58%, respectively), followed by Elarajan (28% and 48%, respectively). Thiruthali was found to have highest litre weight (453 kg/l), followed by ICRI 5 (425 kg/litre). The length and diameter of capsules were maximum (21 mm±3 and 9 mm±0.3, respectively)

in Elarajan. Test weight (weight of hundred capsules) was highest in Thiruthali (25g), followed by Elarajan (22 g). Highest seed to husk ratio was recorded in ICRI 7 and Thiruthali (3.9:1), followed by Elarajan.

P8

Screening of field gene bank accessions of small cardamom (*Elettaria cardamomum* Maton) for morphological, yield, drought and diseases

Sharon Aravind*, C N Biju[1], S J Ankegowda, R Senthil Kumar[2]& Mohammed Faisal Peeran

ICAR-Indian Institute of Spices Research, Regional Station, Appangala-571201, Karnataka
[1]ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
[2]ICAR-IIHR, Central Horticultural Experimental Station, Chettalli-571234, Karnataka
*sharon@spices.res.in

Cardamom being a cross pollinated crop, considerable diversity for various traits exists in the natural population of wild as well as cultivated forms in the Western Ghats. This diversity is exploited for both commercial and scientific interest by conserving in *ex-situ* gene banks and subsequent characterization to identify desirable traits. At ICAR-Indian Institute of Spices Research Regional Station, Appangala, 117 field gene bank accessions of small cardamom were screened for morphological, yield, drought and diseases (rhizome rot and leaf blight). The study indicated that, significant variation exists for morphological characters *viz*., plant height, number of bearing tillers, number of capsules per plant and fresh weight of capsules. Among the accessions, FGB 65 recorded the maximum plant height (350 cm) whereas, maximum number of bearing tillers (36.4) was observed in FGB 16. The accession, FGB 13 recorded maximum number of capsules per plant (244.2) and highest fresh weight of capsules per plant (399.61 g). When the accessions were screened for drought, FGB 41 recorded maximum specific leaf weight (6.83mg/cm^2) and FGB 56 recorded minimum specific leaf weight (4.21 mg/cm^2). Natural incidence of diseases *viz*., leaf blight and rhizome rot were recorded and based on the per cent disease index, 35 cardamom accessions were found to be resistant to leaf blight whereas the accession, FGB 118 was identified as highly resistant to rhizome rot.

P9

Studies on microsporogenesis and pollen formation in *Zingiber officinale* Roscoe

M Muniraja, G Vijaya Lakshmi, H Sunitibala Devi[1], B S Bhau[2]& P S ShaValli Khan*

Department of Botany, Yogi Vemana University, Vemanapuram, Kadapa-516003, Andhra Pradesh
[1]Institute of Bioresources & Sustainable Development,
Takeyalpat Institutional Area, Imphal-795001, Manipur
[2]Medicinal, Aromatic & Economic Plant Division,
North East Institute of Science & Technology, Jorhat-785006, Assam
*pssvkhan@yahoo.com

The present study provides the first description on microsporogenesis and pollen formation in *Zingiber officinale* Roscoe (*Zingiberaceae*). This species is one of the most important vegetable

condiments with proven antioxidant activity. Ginger is widely cultivated in the tropics and sub-tropics and in India, particularly in North-East. This species very rarely produce seeds and it is very difficult to breed new genotypes through sexual hybridization. Classical cytological squash technique and staining protocols with acetocarmin, FDA, DAPI were employed for the study of microspore development as well as assessment of embryogenic window and microspore viability. The study revealed that, the general pattern of microsporogenesis and pollen formation in this species starting from PMCs to binucleate mature pollen grain. The microspore development was divided into four basic stages *viz*., (1) pre-meiotic, (2) the tetrad stage, (3) free microspores and (4) the mature pollen grains. This information enriches the database of cytology, pollen viability estimations and can be useful for hybridization studies. It also contributes to basic information that will hopefully allow the development of doubled haploid protocol for production of androgenic haploids to accelerate breeding and genetic improvement of ginger.

P10

Performance evaluation of ginger (*Zingiber officinale* Rosc.) accessions for yield and quality

R Balakumbahan* & J Prem Joshua[1]

Horticultural College & Research Institute, TNAU, Periyakulam-625604, Tamil Nadu
[1]Agricultural College & Research Institute, TNAU, Killikulam-628252, Tamil Nadu
*hortibala@gmail.com

Diversity in crop species and their cultivars are the key resources for productive agriculture. Being a land of spices, India is having rich crop and species diversity in spices. Most of the genetic resources are neglected and degraded by the modern intensive farming methods. A handful of varieties or hybrids have replaced the practice of ancient phenotypes and local strains which were in cultivation hitherto. The genetic material of extinct varieties, cultivars or wild related species is seldom recovered or reproduced. *Zingiberaceae*, possess different commercially important genera and species. Ginger (*Zingiber officinale* Rosc.) is one of the major and important spices cum condiment popularly grown for its pungent rhizome in the warm humid subtropic regions.A research work was under taken with a vision to identify suitable existing cultivar or accession with higher yield and quality attributes for high rainfall zone. In this context, totally twenty four ginger accessions, local strains and varieties were collected from different ginger growing tracts of India and evaluated for their performance in Pechiparai region. Among them, accession ZO 4 recorded higher fresh rhizome yield (22.16 t/ha), ZO 6 recorded highest dry recovery (22.47 per cent), ZO 5 recorded highest oleoresin content of 9.56 per cent and the genotype ZO 17 recorded highest fibre content of 11.2 per cent.

P11

Somaclonal variation in yield and quality attributes of ginger (*Zingiber officinale* Rosc.)

K Anand*, K Alice, S Asha, K Krishnakumary& N Naresh[1]

Department of Plantation Crops & Spices, [1]Department of Processing Technology,
Kerala Agricultural University, Thrissur-680656, Kerala
*kankanawadi112@gmail.com

A study was conducted at Kerala Agricultural University, Thrissur during 2013-15 to find out the best among forty ginger somaclones, developed through indirect methods of regeneration with and without mutagenesis from two induced polyploids (Z-0-78 from Himachal treated with 0.25% colchicine by injection method and Z-0-86 from Rio-de-Janeiro treated with 0.1% colchicine by hole method) and one diploid cultivar (Himachal) for commercial utilization based on yield and quality attributes. Somaclones, SE 86 81, SE 86 131, SE 86 83 and SE 86 40 recorded higher fresh rhizome yield and somaclones, C 86 23, SE 86 81 and SE 86 41 registered higher dry rhizome yield. Low crude fibre content was observed in somaclones, C 86 8, SEHP 8 and SEHP 74. Somaclones SE 86 40, CHP 99 and C 86 23 and SE 86 81 were found suitable for oil and oleoresin extraction, respectively. From the study it is concluded that, the somaclone, SE 86 81 exhibited multiple usage due to its suitability for fresh as well as dry rhizome yield and oleoresin extraction.

P12

In silico studies on resistance (R) genes from the transcriptome of *Curcuma amada* and *Zingiber officinale* after challenge inoculation with *Ralstonia solanacearum*

R Karthika*, T V Lini, O B Rosana, D Prasath & M Anandaraj

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*karthikarr77@gmail.com

Ginger (*Zingiber officinale*) is a vegetatively propagated plant affected by many diseases including bacterial wilt caused by *Ralstonia solanacearum. Curcuma amada,* belonging to the same family *Zingiberaceae* was found to be unaffected by the pathogen. Hence, an attempt was made to determine the factors governing resistance in the plant. The transcriptome data obtained from wilt-sensitive ginger and wilt-resistant mango ginger, sequenced using Illumina sequencing technology was used for data mining based identification of disease resistance R-genes. Amino acid sequences of known R-genes were used as template to search out similar sequences from *Z. officinale* and *C. amada* database. The identified sequences were categorized into distinct but related protein classes *viz*., serine/threonine-protein kinases, LRR-transmembrane-serine/threonine-protein kinases, NBS-LRR and LRR-transmembrane families, according to their conserved structural domains. Most alignments occurred with monocots with emphasis on *Musa* spp. These detected R-genes can open a way to study the defense mechanism in *C. amada* in response to *R. solanacearum*. Real-time PCR has been carried out to identify the expression profile of a selected NBS-LRR gene in leaf and pseudostem samples of *C. amada* and *Z. officinale* at different hours post-inoculation (hpi) with *R. solanacearum.* The expression of R-gene increased by 11 fold and 3 fold in *C. amada* leaf and pseudostem tissues, respectively

whereas in *Z. officinale*,it was found to be around 1 fold. The finding can bring useful evidences for understanding the defense resistance mechanism in *C. amada.*

P13

Induction of variability in ginger through induced mutation for disease resistance

D Prasath*, R Suseela Bhai & R Ramakrishnan Nair

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*prasath@spices.res.in

Ginger (*Zingiber officinale* Roscoe) is severely affected by bacterial wilt and rhizome rot diseases. The lack of genetic variability among the genotypes for disease resistance is one of the bottlenecks in ginger genetic improvement. Mutation breeding is an important tool in crop improvement of vegetatively propagated crops, particularly in plants with reproductive sterility. The present investigation comprises mutability and radio sensitivity of the ginger genotypes using different doses of gamma rays. Different mutation frequencies and width of mutation spectra were induced under the action of different concentrations of gamma rays (0.5-1.2 kR). High frequency of chlorophyll mutants (5.13%) indicated mutability of ginger. The spectra of chlorophyll mutations (albino, xantha and chlorina) were observed and grouped. The overall mutation spectrum for ginger showed that, xantha occurred with the highest frequency, followed by chlorina and albino. The mutagenic effectiveness decreased with the increase in dose of mutagen indicating negative relationship between effectiveness and dose of mutagen. Based on probit analysis for mortality per cent in gamma irradiated ginger, LD_{50} for seven genotypes (Varada, Mahima, Rejatha, Gorubathan, Acc. 182, Acc. 247 and Acc. 278) was derived. Compared to control, wide variability was recorded for various morphological characters under different doses of gamma rays. Artificial screening of mutants against *Ralstonia solanacearum* and *Pyhtium* sp. led to identification of six potential mutants (HP 0.5/2, HP 0.5/15 and M 0.5/1; V 0.5/2, R 0.8/1 and R 1.25/4) against these two pathogens.

P14

Evaluation of ginger (*Zingiber officinale* Rosc.) genotypes for growth, yield and quality attributes grown under Soppinabetta ecosystem of hill zone of Karnataka

Y Ravi, V B Narayanpur*, J S Hiremath, T Shantappa & V Rathode

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*vbnhort@gmail.com

A field experiment was conducted at College of Horticulture, Sirsi, to assess ginger (*Zingiber officinale* Rosc.) genotypes for growth, yield and quality. The study was conducted under rainfed condition from June 2013 to February 2015. The experiment was laid out with 16 genotypes including nationally recognized varieties in randomized block design with two replications under the partial shade of soppinabetta (forest). The results indicated that, Humanabad Local as the most promising genotype in terms of growth and yield. The growth attributes like plant height (53.25 cm), number of leaves (315)

and leaf area index (20.19) and yield attributes like length of primary fingers (7.41 cm), length of secondary fingers (5.78 cm), rhizome yield plant^{-1} (360.2 g) were highest with Humanabad Local. Humanabad Local recorded highest fresh yield of rhizomes (21.55 t ha^{-1}) and dry recovery (27.35%). The genotype Rio-de-Janeiro recorded maximum essential oil and oleoresin content (2.55% and 8.04%, respectively). The genotype Humanabad Local found on par with Rio-de-Janeiro with respect to quality parameters (2.15% and 7.95% essential oil and oleoresin , respectively). The genotype Himagiri recorded maximum crude fibre content (4.87%) and the least crude fibre was with IISR Varada (3.2%). Under Soppinabetta ecosystem of hilly zone of Karnataka, Humanabad Local performed better with respect to growth, yield and quality parameters.

P15

Genetic variability studies in ginger (*Zingiber officinale* Rosc.) genotypes

Y Ravi, V B Narayanpur*, P M Gangadharappa, V A Betageri & T Shantappa

Department of Plantation Spices Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*vbnhort@gmail.com

A field experiment was conducted at College of Horticulture, Sirsi, to assess the genetic variability in ginger (*Zingiber officinale* Rosc.) genotypes for growth, yield and quality. The study was conducted under rainfed condition from June 2013 to February 2015. The experiment was laid out with 16 genotypes including nationally recognized varieties in randomized block design with two replications under the partial shade of Soppinabetta (forest).The genetic variability, heritability and genetic advance over mean were estimated for yield and quality traits. Wide genetic variation was observed for all the genotypes for plant height, number of leaves per plant and fresh yield per plant. GCV was found highest for number of leaves (28.64%), followed by oleoresin content (20.64%) and fresh yield per plant (18.12%). With respect to all morphological characters, the phenotypic variances were higher than the genotypic variances. Heritability (h^2 b.s.) was found highest for fresh yield per plant (89.2%), oleoresin content (80.3%), stem girth (79.39%), number of leaves per plant (75.69%) and plant height (67.93). High genetic advance as mean (GA) was observed for number of leaves (51.32%), oleoresin content (38.11%) and fresh yield per plant (35.26%), indicating additive gene effect.

P16

Performance behaviour of ginger (*Zingiber officinale* Rosc.) genotypes with respect to quality under coconut ecosystem

K S Sangeetha* &S Subramanian

Department of Spices & Plantation Crops,
Horticultural College &Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*sangy.666@gmail.com

An experiment on performance behaviour of ginger for quality under coconut ecosystem was carried out with thirty genotypes at HC & RI, TNAU, Coimbatore during 2012-2013. The quality attributes *viz.,*

oleoresin, crude fibre and essential oil content were analyzed after harvest (240 days after planting). The genotype, ZO 26 (Idukki 2) recorded higher essential oil content (2.1%), followed by ZO 29, 9 and 21 (2.06, 2.05 and 2.03%, respectively) and were on par with each other. The genotype ZO 5 recorded lesser essential oil content (1.51%). Higher crude fibre content (6.21%) was recorded in ZO 4, followed by ZO 24 (5.74%) and ZO 6 (5.69%) and both were on par with each other. The genotype ZO 28 recorded lesser crude fibre content (3.18%). The genotype, ZO 18 recorded higher oleoresin content (9.9%) and lesser oleoresin (5.5%) was recorded in ZO 24. Based on the results, ZO 26 (Idukki 2) can be considered as the suitable genotype for essential oil and ZO 28 for fresh ginger purpose.

P17

Studies on growth, physiology, yield and quality of ginger (*Zingiber officinale* Rosc.) genotypes under coconut shade

D Arun, S Subramanian* &J Suresh

Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*hrstkd@tnau.ac.in

A field experiment was conducted to study the growth, physiology, yield and quality of ginger (*Zingiber officinale* Rosc.) genotypes under coconut shade during 2014-2015 at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in RBD with two replications using thirty five ginger genotypes. Among the genotypes, higher sprouting percentage (100%) was recorded in ZO 23 and ZO 26. The genotype, ZO 26 produced taller plants (59.2 cm), higher number of leaves (148.74), more number of tillers (9.9), higher leaf area per plant (2371.38 cm^2), leaf area index (3.51) and higher dry matter accumulation (63.42 g/plant). The genotype, ZO 26 was also found superior for plant yield (175.69 g), plot yield (2.64 kg) and estimated yield (26.4 t ha^{-1}) at 180 DAP. The genotype, ZO 26 produced higher number of mother rhizomes (2.86), higher number of primary rhizomes (6.27) and higher number of secondary rhizomes (6.33). At 240 DAP, ZO 26 was found superior for plant yield (177.85 g), plot yield (2.75 kg) and estimated yield (27.5 t ha^{-1}), followed by ZO 28 which recorded 163.93 g plant yield, 2.7 kg plot yield and 27 t ha^{-1} estimated yield. The genotype, ZO 22 recorded higher dry recovery (26.18%). The genotype, ZO 26 recorded higher essential oil content (1.83%), ZO 4 recorded higher crude fibre content (5.52%) and ZO 18 recorded higher oleoresin content (9.04%). The benefit-cost ratio was higher in ZO 26 (8.46). It is concluded that, performance of the genotype, ZO 26 (Kanchiyar Local) was better followed by ZO 28 (Thangamani Local) under coconut shade condition.

P18

Evaluation of turmeric germplasm for their resistance against foliar diseases

P Muthulakshmi

Department of Fruit Crops,
Horticultural College & Research Institute,TNAU, Coimbatore-641003, Tamil Nadu
muthupathology@gmail.com

Turmeric (*Curcuma longa* L.) is an important commercial crop grown for its underground rhizome which is widely used as condiment, dye and medicine. Among the fungal diseases, leaf spot caused by *Colletotrichum capsici*, leaf blotch caused by *Taphrina maculans* and rhizome rot caused by *Pythium aphanidermatum* are the major diseases. The sources of tolerance/resistance to these diseases are almost not available so far. Therefore, a field trial was laid out with 275 turmeric germplasm entries to screen against foliar diseases *viz*., leaf spot and leaf blotch diseases during 2012-13 using 1-5 scale. The leaf spot intensity ranged from 14.00-60.00 PDI. The accession *viz*., CL 32 recorded the least leaf spot intensity of 14.00 PDI with maximum yield of 60.67 t/ha followed by CL 34 and CL 54 (16.00 PDI) with yield of 56.13 t/ha and 57.47 t/ha, respectively. The other accessions *viz*., CL 33, 52 and 80 recorded the leaf spot intensity of 18.00 PDI with the yield of 56.13, 63.33 and 51.67 t/ha, respectively. The highest leaf spot intensity of 60.00 PDI was recorded in CL 135 with the lowest yield of 26 t/ha. The leaf blotch intensity ranged from 14.00-68.00 PDI. The accessions CL 34 and 101 recorded the least intensity of 14.00 PDI with yield of 56.13 t/ha and 62.13 t/ha, respectively followed by CL 32 and CL 101 which recorded the disease intensity of 16.00 PDI with the highest yield of 60.67 t/ha and 62.13t/ha, respectively. The other accessions *viz*., CL 52 and CL 54 recorded the leaf blotch intensity of 18.00 PDI with a yield of 63.33 t/ha and 61.33 t/ha, respectively. The highest leaf blotch intensity of 68.00 PDI was recorded in CL 12 with the lowest yield of 29.67 t/ha.

P19

Evaluation and identification of turmeric genotypes for desired yield and quality attributes

P Hemalatha* & R Chitra

Agricultural Research Station, TNAU, Bhavanisagar-638451, Erode, Tamil Nadu
*hemahort@yahoo.com

An experiment was conducted at Agricultural Research Station, Bhavanisagar during June 2012 to May 2015 to evaluate 156 turmeric accessions and identify genotypes for desired yield and quality attributes. The observations on growth parameters recorded during the active growth phase (3rd month), rhizome formation phase (5th month) and rhizome development phase (7th month) indicated that, at early stage of growth, the extent of variation was low among the accessions for all the growth characters. The severity of leaf spot was low (PDI<10%) in the accessions BS 9, CL 199, CL 147, BS 79, BS 34, BS 32 and BS 17 while, leaf blotch was less in BS 79 with minimum occurrence (PDI 11.11%). The accessions BS 9, CL 149 and BS 17 were found resistant to both leaf thrips and shoot borer infestations. Among the 156 accessions, the accession, BS 9 recorded higher fresh rhizome yield per plant (559 g), estimated yield (52.17 t/ha), cured rhizome yield (10.65 t/ha) and curcumin content (4.38%) consecutively over all the period of the study. Moreover, the estimated mean yield per hectare and curcumin content of the above accession was found higher compared to all the existing turmeric varieties released by TNAU *viz.,* CO 1, BSR 1, BSR 2 and CO 2.

P20

In vitro multiplication of turmeric (*Curcuma longa* L.) cv. BSR 2

Sharon Aravind* & G Balakrishnamurthy

Department of Spices & Plantation Crops,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*sharonrvnd@gmail.com

An efficient regeneration method was developed for *Curcuma longa* L. (cv. BSR 2) using fresh sprouting rhizome buds on semi-solid culture media. The explants (rhizome buds) were cultured on Murashige and Skoog's (MS) medium supplemented with different concentrations and combinations of BAP (6-benzyl-amino-purine) and NAA (α- naphthalene acetic acid) for shoot and root induction. Explants cultured on MS medium supplemented with 2 mg l^{-1} BAP + 0.1 mg l^{-1} NAA produced the maximum number of multiple shoots (8) and the longest shoots (4.5 cm). Largest number of roots (9.61) and the longest roots (6.04 cm) were produced in the medium composition of half MS + charcoal (0.5 g l^{-1}) supplemented with IAA (1 mg l^{-1}) and IBA (1 mg l^{-1}).The regenerated plantlets were transferred to cups containing cocoa peat medium and kept in mist chamber at a temperature of 28 ± 2˚C and 70-80% relative humidity for 30 days. During hardening, the survival rate was found to be 98.89% and the best hardening response with tall plants (15 cm) and more leaves (5) was observed in the potting media composition of sterile soil with coir compost and vermicompost (1:1:1). The protocol so developed in the present study *via* direct regeneration system could be exploited to develop disease-free quality planting materials that could be stored and transported easily which is a step towards commercial scale of propagule production in turmeric cv. BSR 2.

P21

PDKV- Waigaon new variety of turmeric for high yield and curcumin

V S Kale*, P K Nagre, V N Dod & S G Bharad

Department of Horticulture,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444104, Maharashtra
*vijayskale72@gmail.com

Station trials (2007-08 and 2008-09) and multi-location trials were conducted at different locations (2009-10, 2010-11 and 2011-12) for evaluation of turmeric entries for yield and yield contributing characters with Phule Swarupa and Krishana as checks. The higher number of leaves was recorded in the genotype PDKV Waigaon while, the lowest was recorded in Local Waigaon. The maximum days

from planting to harvesting was recorded with Phule Swarupa, followed by Krishana and was the minimum in genotype GDT 06/01. The finger length was the maximum in genotype PDKV Waigaon, which was at par with genotype GDT 06/01. The yield of mother rhizome per plant (g) over years and over locations was found maximum in Phule Swarupa, followed by PDKV Waigaon. Maximum finger yield was recorded in PDKV Waigaon and minimum in Local Waigaon. Similarly, pooledmean for yield of cured finger rhizomes and curcumin content were also maximum in PDKV Waigaon (6.1).

P22

Yield performance of initial evaluation trial on turmeric (*Curcuma longa* L.)

V P Pandey*, R S Mishra, V P Singh & R K Gupta

Department of Vegetable Science,
ND University of Agriculture & Technology, Kumarganj-224229, Uttar Pradesh
*vppandeynduat2012@gmail.com

Turmeric, the golden spice of life is one of most essential spice used as an important ingredient in culinary all over the world. There is dearth of knowledge on the stability of germplasm/cultivars released so far. Therefore, ten entries of turmeric including two checks (Prabha and NDH 1) collected from different centers of All India Co-ordinated Research Project on Spices were evaluated at Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, U.P. The experiment was conducted in a plot size of 3 X 1 m^2 at spacing of 30 X 20 cm in three replications during 2014-15. The maximum yield of fresh rhizome, 331.10 q/ha was recorded with NDH 74, followed by NDH 11 (305.55 q/ha), NDH 40 (274.99 q/ha), NDH 128 (263.88 q/ha), NDH 139 (256.66 q/ha), NDH 114 (255.55 q/ha), NDH 1 (255.55 q/ha), Prabha (249.99 q/ha), NDH 10 (238.88 q/ha) and NDH 133 (208.33 q/ha). The present investigation revealed that, NDH 74, NDH 11, NDH 40, NDH 128, NDH 139 and NDH 114 were superior over the checks.

P23

Molecular and quality characterization of selected turmeric (*Curcuma longa* L.) genotypes

V A Muhammed Nissar*, D Prasath[1]& B Sasikumar[1]

Division of Horticulture,
ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya
[1]ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*muhammednissar@gmail.com

Ten genotypes of turmeric comprising of three pre-release selections (Accessions 48, 79, 849) and seven released varieties (IISR Prabha, IISR Prathibha, IISR Kedaram, Suguna, Suvarna, Rajendra Sonia and Megha turmeric 1) were evaluated for quality and characterized using SSR and RAPD markers during 2015. The varieties Suvarna (24.2%) and Prathibha (24%) recorded highest dry recovery and

the lowest was recorded in Acc. 79 (15.66%). IISR Prathibha (13.84%) and Rajendra Sonia (13.62%) were superior in terms of oleoresin and curcumin was highest in IISR Kedaram followed by Acc. 48. Oil content among accessions ranged from 2.8% to 3.2%. Among 20 RAPD primers tested, 13 were amplified out of which, 7 primers generated interpretable polymorphic amplification. The lowest and highest PIC values of 7 RAPD primers were 0.336 (OPN-16) and 0.396 (OPA-7), respectively with an average of 0.365. In the case of 10 microsatellite (SSR) primers attempted, 8 primers were amplified out of which, 5 were polymorphic. The lowest PIC value recorded was 0.18 for CLM-34 and the highest was 0.5 for CLM-33 and Cumisat-20 with an average of 0.25. Accession number 849, a morphologically distinct genotype showed maximum number of specific bands for the primers attempted. The Jaccard's similarity coefficient ranged from 0.49-0.92 for the 10 genotypes. The genotypes formed two major clusters in which, accession 849 distinguished from the remaining genotypes that had grouped together. Principal Coordinate Analysis (PCoA) also revealed similar clustering as observed by UPGMA based dendrogram. RAPD and SSR markers were found to be effective in characterizing and diversity analysis of turmeric.

P24

Evaluation of turmeric (*Curcuma longa* L.) cultivars for yield and quality under southern dry zone of Karnataka

Siddalingayya Salimath*, J Venkatesha, Y K Kotikal & Raviraj Shetty

University of Horticultural Sciences, Bagalkot-57103, Karnataka
*salimath.salimath@gmail.com

Turmeric (*Curcuma longa* L.), a *Zingiberaceous* perennial herb is an important spice and medicinal crop native to South East Asia. It is essential to standardize production, processing techniques for its quality and high productivity. Among the sixteen turmeric cultivars tested in southern dry zone of Karnataka, maximum fresh rhizome yield was observed in Salem (33.67 t ha^{-1}) which was on par with Rajapuri (32.67 t ha^{-1}), Prathibha (32.56 t ha^{-1}) and CLT 325 (20.99 t ha^{-1}). The highest curing percentage was recorded in Salem (24.7) which was on par with CLT 325 (24.51) and Erode Local (24.16). The minimum curing percentage was found in CLT 14 (20.01). Maximum processed cured turmeric rhizome yield was obtained in Salem (8.31 t ha^{-1}), CLT 325 (7.98 t ha^{-1}) and Co1 (7.01 t ha^{-1}). With respect to quality in terms of curcumin content, PTS 24, Prabha, Prathibha, CLT 325, Salem and Rajapuri were superior (7.2%, 6.45%, 6.39%, 5.76%, 4.56% and 4.62%, respectively). On the basis of yield and quality characters the turmeric cultivars Salem, Rajapuri, Prathibha and CLT 325 were identified as promising and suitable cultivars for southern dry zone of Karnataka.

P25

Evaluation of genetic divergence in turmeric (*Curcuma longa* L.)using biometric tools

Vijayalatha

Krishi Vigyan Kendra, TNAU, Tirur-602025, Tamil Nadu
gangaviji2007@gmail.com

A study was undertaken to exploit already existing land race variability and document clear-cut information on the extent of genetic diversity available in turmeric. A cluster tree was constructed involving 22 quantitative traits using K means clustering based on Euclidean distance. The K means grouped the genotypes into five clusters. Among the genotypes from Orissa, PTS 2 was distinct from others and clustered with Bhavanisagar genoytpes. The genotype, Rajendra Sonia was distinct from rest of the genotypes. Principal component analysis was implied in the current study, three factors were found to contribute for more than 80 per cent of total variability. The first component was dominated by weight of primary and secondary rhizomes and their dimensions. The phenotypic effects produced interpreted for the existing variability among the genotypes, which is interpreted by the positive and negative scores. The study indicated that, this variability could be exploited in turmeric breeding and these characters are likely to be linked together and behave alike during inheritance and another possibility of being governed by independent set of alleles.

P26

Highly conserved sequence of *clpks11* is a novel gene involved in *de novo* curcumin biosynthesis in turmeric (*Curcuma longa* L.)

K Deepa, T E Sheeja*, O B Rosana & B Sasikumar

Division of Crop Improvement & Biotechnology,
ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*sheeja@spices.res.in

Curcuma longa L., is an important rhizomatous medicinal spice belonging to the family *Zingiberaceae*. Therapeutic properties of turmeric are mainly due to curcuminoids and polyketide synthases (PKS) are important class of downstream enzymes involved in the biosynthesis of curcumin. Transcriptome analysis of *Curcuma* identified sixty three homologous transcripts of *pks* of which, *clpks11* showed 88 fold expression in high curcumin turmeric variety compared genotype with low curcumin content. In the present study, expression analysis of genes encoding already reported PKS *viz.,* curcumin synthases (*curs*1-3*)*, diketide CoA synthase (*dcs*) and a novel *clpks11* was carried out in two genotypes of turmeric *viz*., IISR Prathibha (high curcumin) and Acc. 449 (low curcumin) under favourable and unfavourable environments for curcumin biosynthesis. Quantitative Real time PCR expression of *clpks11* showed a significant positive correlation with curcumin content, indicating its probable role in biosynthesis. Hence, full length cDNA of *clpks11* was cloned from a library of pooled turmeric tissues. Blastp analysis indicated the unique status of CLPKS11 with a maximum homology of 72% with CURS3. Multiple sequence alignment of deduced amino acid sequences of CLPKS11 with already reported PKS in the NCBI revealed high conservation in the catalytic triad residues, six residue loop,

cis-peptide bond residues and gatekeepers. However, amino acid differences existed in the substrate binding pocket, cyclization pocket and geometry shapers surrounding the active site. Molecular docking studies indicated higher substrate affinity for CLPKS11 in comparison with CURS1, a closely resembling CLPKS in PDB database.

P27

Evaluation of suitable high yielding turmeric varieties with resistance to pests and diseases in Salem district of Tamil Nadu

B Geetha* & N Sriram

Krishi Vigyan Kendra, TNAU, Sandhiyur-636203, Salem, Tamil Nadu
*geethaentomology@yahoo.com

A study was undertaken to evaluate location specific high yielding turmeric varieties *viz*., CO 2, BSR 2, IISR Prathibha, Alleppey Supreme and Roma for pests and disease resistance with Salem Local as check through on farm trials in Salem during 2013-16.The results indicated that, the varieties CO 2, BSR 2, IISR Prathibha and Alleppey Supreme were resistant to leaf spot, blight and rhizome rot diseases and field tolerant to thrips and stem borer compared to Salem Local. The variety, CO 2 was found to be highly resistant, Alleppey Supreme, Roma, IISR-Prathibha were resistant, BSR 1 and 2 were moderately resistant and Salem Local was susceptible to leaf spot/blight and rhizome rot diseases. The nematode infestation was severe in Salem Local and BSR 2 compared to other varieties. Fresh rhizome yield of 28 to 32 t/ha was recorded in CO 2, IISR Prathibha and Alleppey Supreme compared to 20 to 22 t/ha in Roma and Salem Local. The dry recovery was higher in Roma (30%) compared to other varieties. The study indicated that, CO 2, Roma, IISR-Prathibha and Alleppey Supreme as alternatives for local variety in Salem district.

P28

Genetic variability analysis in coriander (*Coriandrum sativum* Linn.) genotypes

R Chitra*, P Suganya, S Subramanian[1], A Ramar & J Suresh

AICRP on Spices, Department of Spices & Plantation Crops,
Horticulture College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[1]Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*chitra.varadharaj@gmail.com

Coriander (*Coriandrum sativum* L.) is an annual spice that belongs to the family Apiaceae. In India, it is mainly grown in Rajasthan, Madhya Pradesh, Andhra Pradesh and Tamil Nadu. Despite its importance, the productivity of coriander continues to be low (519 kg ha^{-1}) with poor essential oil content (0.04 to 0.8 per cent). Thus, there is great scope for crop improvement for increasing yield and quality. Information on extent of variation, heritability and expected genetic advance in respect of yield and yield determining traits is lacking in coriander. The present investigation was undertaken to assess the genetic parameters in respect of yield and yield determining characters of twenty genotypes of

coriander. High genotypic and phenotypic coefficients of variation were accounted for number of umbels (35.21, 35.21), seed yield per plant (32.29, 33.16) and number of secondary branches (26.78, 26.84). Seed yield was positively associated with several characters such as days to 50% flowering, days to maturity, number of umbellets and days to first flowering. Quantitative traits like plant height, number of secondary branches, days to flowering, days to 50% flowering, number of umbels and days to maturity exhibited wide range of variability, maximum genotypic and phenotypic coefficient of variability, broad sense heritability and genetic gain (as per cent of mean). It was found that, the genotypes RCr 728, COR 41 and CO (CR) 4 were promising.

P29

Screening of germplasm entries for the management of powdery mildew in coriander

C Ushamalini*, R Chitra & J Suresh

AICRP on Spices, Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*ushackadir@yahoo.co.in

Coriander is an important culinary spice of daily usage as green leaves and seed. Among the several diseases, powdery mildew caused by *Erysiphe polygoni*, is an important disease in coriander growing tracts of Tamil Nadu. To find out the resistant sources, a field trial was conducted during 2014-15 (*rabi*) at Horticultural College and Research Institute, Coimbatore. A total number of 275 germplasm entries were screened for the incidence of powdery mildew using 0-4 scale and PDI was calculated. Among the 275 germplasm entries screened, the incidence of powdery mildew disease was noticed in all the accessions. The PDI ranged from 12.50 to 83.33. The accessions *viz*., CS 46, 58, 105, 221 and 228 recorded the least disease intensity of 12.50 PDI with the highest yield of 440-660 kg/ha. The highest intensity of powdery mildew was recorded in CS 67, 246, 256 and 256 (83.33 PDI) with the lower yield of 400-500 kg/ha.

P30

Correlation between essential oil and seed yield of promising genotypes of coriander (*Coriandrum sativum* L.)

G K Mittal*, A C Shivran, Dhirendra Singh, D K Gothwal&Bhuri Singh

ICAR-All India Coordinated Research Project on Spices,
SKN College of Agriculture, SKNAU, Jobner-303329, Rajasthan
*mittalgkumar@gmail.com

An experiment was conducted under AICRP on seed spices at Jobner, Jaipur during *rabi* 2012-15 to evaluate twenty four promising genotypes for essential oil and seed yield. Performance of the genotypes revealed the superiority of JCr 379 (2347.22 kg/ha), followed by DH 306 (2245.21 kg/ha), RD 385 (2197.99 kg/ha), RD 377 (2144.75 kg/ha), NDCor 10 (2107.56 kg/ha) and ACr 2 (2039.66 kg/ha) while, lowest seed yield (1046.45 kg/ha) was recorded in PD 7. The analysis of variance

revealed significant differences among the genotypes for essential oil (%). The highest essential oil content (0.6%) was recorded in LCC 224 (COR 85) and LCC 219 (COR 84) (0.59%) and LCC 242 (COR 86), followed by JCr 379 (COR 93) (0.55%) and ACor 2 (COR 82) (0.54%) whereas, minimum (0.35%) was recorded in RCr 728 (NC 2), followed by 0.38% in RD-385 (COR 92). The maximum volatile oil yield was observed in JCr 379 (COR 93) (12.88 l/ha), followed by PD 21 (COR 87) (11.16 l/ha), ACor 2 (COR 82) (10.92 l/ha), ND Cor 10 (COR 81) (10.75 l/ha), LCC 224 (COR 85) (10.2 l/ha) and minimum in RKD 21 (COR 74) (5.08 l/ha) and RKD 39 (COR 75) (5.61 l/ha). Non-significant negative correlation (r=-0.337) was obtained between essential oil content and seed yield.

P31

Studies on the performance of coriander (*Coriandrum sativum* L.) genotypes for growth, yield and quality

P Suganya, S Subramanian*, R Chitra & J Suresh

Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*hrstkd@tnau.ac.in

Identification of varieties/cultivars of coriander for higher yield is highly imperative considering ever increasing demand in India and abroad. With this background, studies on performance of coriander (*Coriandrum sativum* L.) for growth, yield and quality was undertaken at HC & RI, Coimbatore, Tamil Nadu.The coriander genotypes were collected from different parts of Tamil Nadu, Haryana, Uttar Pradesh, Andhra Pradesh, Punjab and Rajasthan. Among the genotypes, RCr 728, COR 41 and CO (CR) 4 recorded higher plant height, more number of primary and secondary branches, higher content of chlorophyll a, chlorophyll b, total chlorophyll, total dry matter production, higher number of umbels per plant, umbellets per umbel and high seed to powder ratio. These genotypes also showed precocity in days to first flowering, days to 50% flowering and days to maturity. The genotypes, COR 36, COR 40 and ACr 1 recorded the highest essential oil, oleoresin and soluble protein content.

P32

Evaluation of fenugreek genotype (NDM 69) for seed yield and downy mildew disease resistance

R S Mishra & V P Pandey*

Department of Vegetable Science,
ND University of Agriculture & Technology, Kumarganj-224229, Faizabad, Uttar Pradesh
*drramsumanmishra@gmail.com

Downy mildew of fenugreek was first recorded from Maharashtra and now occurs during February and March in Punjab and UP, causing heavy yield loss. Infected leaves are easily detected by the presence of yellow patches on the upper surface. An experiment was carried out under All India co-ordinated varietal trials from 2012-13 to 2014-15 at N.D. University of Agriculture & Technology, Kumarganj, Faizabad, UP with 16 genotypes including 2 checks for evaluation to downy mildew

resistance . The disease severity of downy mildew was recorded in the last week of March for all three growing season. The lowest per cent disease severity was recorded in NDM 69 during 2013-14 (5.27), followed by 2012-13 (6.5) and 2014-15 (7.87) among all the 16 genotypes. The highest disease severity was recorded in local check NDM 89 (76.32%) during 2014-15. Whereas, three years pooled data revealed that, NDM 69 recorded highest seed yield 12.9 q/ha followed by HM 280-1 (12.84 q/ha), HM 259 (12.75 q/ha) and AFG 6 (12.61 q/ha).

P33

Identification of potential genotypes of fenugreek in rainfed vertisols for yield and diosgenin content

K Giridhar*, S Surya Kumari, A Rajani[1], C Sarada[1]& L Naram Naidu[2]

AICRP on Spices,
[1]AICRP on Vegetable Crops,[2]Chillies Improvement Project,
Horticultural Research Station, Dr. YSR HU,Lam, Guntur-522034, Andhra Pradesh
*gkalidasu@yahoo.com

Fenugreek (*Trigonella foenum-graecum* L.) is one of the major seed spices grown in many parts of the world. Due to its unique nutritional, aromatic, flavour, medicinal and nutraceutical properties, the crop has attained industrial crop status. The average productivity in India is low, mainly due to the paucity of high yielding varieties (HYVs) and inadequate access of the seed of available HYVs to the growers. In view of this, the present study was undertaken for three years (2009-12) to evaluate thirteen promising genotypes for both yield and diosgenin content. Maximum yield was recorded in genotype LFC 103 (584.1 kg ha^{-1}), followed by HM348 (542.8 kg ha^{-1}). The diosgenin content and productivity in the genotypes varied significantly. Local cultivar recorded significantly higher diosgenin content (0.92%). The highest diosgenin productivity was recorded with UM 364 (3.97 kg ha^{-1}), followed by NDM 119 (3.91 kg ha^{-1}).

P34

Hisar Methi 348: A high yielding variety of fenugreek

S K Tehlan* & T P Malik

Department of Vegetable Science,
CCS Haryana Agricultural University, Hisar-125004, Haryana
*sktehlan07@gmail.com

Fenugreek (*Trigonella foenum-graecum*), known as Methi or Metha is an important multi-use seed spice crop cultivated in India. A research work was carried out at CCS Haryana Agricultural University, Hisar with the objective to develop high yielding variety of fenugreek suitable for leaf as well as seed production under Haryana conditions, which resulted in the development of Hisar Methi 348 (HM 348), a high yielding variety through pure line selection. HM 348 recorded the highest yield of 26.53 and 22.98 q/ha under IET and CVT, respectively which was 24.61 and 17.13% higher over national

check, Hisar Sonali. This variety is suitable for growing for leaf (leaf yield of 74.5 q/ha after one cutting and 132 q/ha after two cuttings) as well as for seed purpose (25 q/ha). It takes about 35-40 days after sowing for first cutting of leaves and next 15-20 days for second cutting and 135-140 days for maturity as seed crop. In view of its superior performance compared with national and other standard checks at Hisar and other co- ordinating centers and being less susceptible (23.5% incidence) to powdery mildew disease, this variety was recommended for release during XXIVWorkshop/Group meeting of All India Co-ordinated Research Project on Spices held at Jagudan, Gujarat.

P35

Performance evaluation of chilli varieties under polyhouse conditions

Sheeba Rebecca Isaac*, K G Lijimol & Linu George

Farming Systems Research Station, KAU, Sadanandapuram, Kottarakkara-691550, Kerala
*sheebarebecca@yahoo.co.in

Production technologies in crops aim at maximum yield per unit area. The trend in the state has been towards hi-tech agriculture, which, although cost intensive, assures bountiful returns that attracts more farmers to shift to the new practice. Protected cultivation popularizes the use of hybrid varieties for higher yields and returns. Spice crops, chilli and coriander are suitable for polyhouse cultivation. Keeping this in view, a field trial involving different improved varieties of chilli was attempted to evaluate their suitability for cultivation in naturally ventilated polyhouses. Five varieties of chilli *viz*., Jwalasakhi, Thejas, Anugraha, NS 1701 and Vidyul (Hybrid) were raised in RBD in the polyhouse at Farming Systems Research Station, Sadanandapuram, Kottarakkara during May to October 2015. The results revealed maximum growth, flowering and fruit yields in hybrid Vidyul followed by NS 1701. A total of 12 pickings were done at weekly intervals. Early flowering was observed in Jwalasakhi and Anugraha. The variety, Thejas recorded profuse vegetative growth with very low number of flowers and fruits revealing its non-suitability for cultivation in polyhouses. Among the four varieties, NS 1701 proved to be the best in terms of yield, followed by Jwalasakhi and Anugraha. However, the former two showed susceptibility to bacterial leaf blight. Vidyul also proved superior in terms of its attractiveness, with dark green colour of the fruits thus proving that, hi-tech cultivation is best with hybrid varieties.

P36

Influence of reducing and non reducing sugar contents on reaction to anthracnose disease in hybrids and parents of chillies (*Capsicum annuum* L.)

G Malathi* & D Veeraragavathatham

Horticultural College & Research Institute for Women, TNAU, Trichy-641009, Tamil Nadu
*malathihort@gmail.com

A field experiment was conducted at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to find out the influence of reducing and nonreducing sugar contents on reaction to anthracnose disease in hybrids and parents of chilli. Based on the disease reaction to anthracnose under natural conditions, a total of eight lines were selected and used for hybrid development programme. Based on the study on evaluation of parents and hybrids, seven parents and three hybrids were found resistant and nine other hybrids were found moderately resistant. These twelve hybrids and their seven parents along with one susceptible check (CHD 8) were selected for the study. Results showed that, with regard to total sugar content, the healthy ripe fruits of all the genotypes recorded low total sugars compared to that of green mature fruits. When compared to healthy fruits, infected fruits recorded reduced level of total, reducing and nonreducing sugar content. A higher decrease in sugar content was recorded in CHD 8 which showed 49.9% infection. Reducing sugars were observed to increase in infected tissues as compared to healthy ones, while nonreducing sugars were found to reduce. Decrease in reducing sugars in infected tissues could be attributed to the assimilation of host carbohydrates by the pathogen or due to increased respiration of host tissues to combat attack of the pathogen.

P37

Influence of total and OD phenol contents on reaction to anthracnose disease in hybrids and parents of chillies (*Capsicum annuum* L.)

G Malathi* & D Veeraragavathatham

Horticultural College and Research Institute for Women,TNAU, Trichy-641009, Tamil Nadu
*malathihort@gmail.com

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lower in susceptible check compared to other resistant and moderately resistant genotypes. The per cent increase in phenol content increased with increase in per cent disease index. With respect to OD phenol content also, infected leaves and fruits recorded higher content than healthy leaves and fruits, respectively in all the genotypes. In healthy tissues of susceptible check and other genotypes there was not much difference. But infected leaf and fruit tissues of susceptible check recorded lower OD phenols than resistant/moderately resistant genotypes.

P38

Heterobeltiosis and inbreeding depression for fruit yield and its components in hot pepper (*Capsicum annuum* var. *annuum*)

N Rohini* & V Lakshmanan

Department of Vegetable Crops,
Horticultural College & Research Institute,TNAU, Periyakulam-625604, Tamil Nadu
*rohizna@gmail.com

A diallel study was conducted during 2012-13 and 2013-14 at Horticultural College and Research Institute, Periyakulam, TNAU, Coimbatore to assess the extent of heterosis and inbreeding depression in chilli. Five crosses namely, K 1 x Arka Lohit, LCA 625 x K 1, Pusa Jwala x K 1, Pusa Jwala x PKM 1 and K 1 x PKM 1 exhibited higher percentages of heterobeltiosis, revealing involvement of non-additive genes and these crosses may be considered as the promising crosses for yield. The crosses recorded higher heterobeltiosis in F_1 whichshowed low inbreeding depression in F_2 generations. The desirable inbreeding depression that is negative in direction was observed in K 1 x PKM 1 and K 1 x Pusa Jwala for yield and yield contributing characters. Significant and positive heterosis with low inbreeding depression for yield and yield related traits were exhibited by Pusa Jwala x PKM 1, LCA 625 x K 1and K 1 x Arka Lohit. The segregating materials generated in F_2 generation may be utilized for the identification and selection of desirable recombinants in advanced generations in order to develop high yielding varieties with specific attributes.

P39

Collection and evaluation of garlic germplasm for high yield and quality (*Allium sativum* L.)

V P Santhi, N Selvaraj[1]& M Jawaharlal*

Horticultural College & Research Institute for Women, TNAU, Trichy-620009, Tamil Nadu
[1]Horticultural Research Station, TNAU, Ooty-643001, Tamil Nadu
*sohort@tnau.ac.in

Garlic (*Allium sativum* L.), is commercially cultivated throughout the world and in India. Besides culinary purposes, garlic is considered as a valuable medicinal spice. Being an asexually propagated crop, most of the varieties developed are through introduction and clonal selection. Therefore, the present investigation was undertaken to identify a high yielding accession with large sized cloves per

bulb and quality during 2010-2014 at Horticultural Research Station, Ooty. Among the 72 accessions, 22 were collected through All India Network Project on Onion and Garlic and rest of the collections were made from different parts/villages of Nilgiri, Tamil Nadu. The accessions were collected and evaluated during the main season (May-August) for four years (2010-2014). Pooled analysis data of four years revealed that, the accession, As 72 recorded the maximum plant height (67.92 cm) with erect green foliage, number of leaves (6.75), maximum equatorial diameter (45.78 mm), polar diameter (42.39 mm), maximum number of cloves (15.76) and highest yield (16.94 t/ha), followed by As 11 (13.7 t/ha). Among the 72 entries, accession As 72 recorded the maximum TSS content (47◦Brix), allicin (3.87 µg/g) and polyphenol (3.08 µg/g), followed by As 11 with TSS (42◦Brix), allicin (3.16 µg/g) and polyphenol (3.49 µg/g).

P40

Studies on the performance of certain garlic (*Allium sativum* L.) accessions for yield and quality under Niligiri conditions

A N Minhaj, P Paramaguru* & J Suresh

Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*paramagurup@yahoo.co.in

Garlic (*Allium sativum* L.), has been cultivated since ancient times all over the world especially in Asia. In order to evaluate the performance of different garlic accessions in Nilgiris, an experiment was carried out with thirteen accessions and two varieties at Horticultural Research Station, Ooty, during 2014-2015. The results revealed that, among the thirteen accessions, maximum plant height (89.61 cm), number of leaves (7.94), leaf width (3.89 cm), pseudostem length (3.89 cm), pseudostem diameter (4.9 cm), average bulb weight (40.67g), ten cloves weight (27.85 g) and yield (17.1 t/ha) were recorded in the accession, As 72 compared to Bheema Purple which recorded the maximum number of cloves per bulb (19.8). The accession, As 72 recorded highest polyphenol (3.52 µg/g), allicin (3.87 µg/g) and total soluble solids (47°B). Variability studies revealed that, allicin content, marketable yield, yield per plot and hectare recorded high values for PCV and GCV. Correlation studies with yield per hectare showed a positive and significant association with plant height, number of leaves, leaf length, polar diameter, number of cloves, polyphenol content, total soluble solids, marketable yield and yield per plot.

P41

Studies on evaluation of garlic cultivars for yield under Nilgiris condition

M Anand, D Venkatesan, A Sankari, S Karthikeyan & B Anita

Horticultural Research Station, TNAU, Ooty-643001, Tamil Nadu
*anandhort@yahoo.com

An investigation was carried out to evaluate the performance of garlic cultivars at Horticultural Research Station, Tamil Nadu Agricultural University, Ooty during 2013-14. Among the cultivars evaluated, maximum plant height was recorded in GN14-05 (69.48 cm), followed by GN14-07 (65.66 cm) and GN14-07 (61.72 cm). Higher numbers of leaves were produced by GN14-05 and Ooty 1 (5.2). GN14-05 recorded maximum leaf length (51.94 cm) and leaf width (2.3 cm). Maximum pseudostem length was recorded in GN14-05 (45.85 cm), followed by Ooty 1 (42.31 cm) and GN14-09 (41.86 cm). The cultivar Ooty 1 recorded the maximum pseudostem diameter (4.8 cm) followed by GN14-05 (4.2 cm) The cultivars *viz.,* GN14-05, Ooty 1 and GN14-01 produced maximum bulb weight (213.08 g, 152.03 g and 134.07 g, respectively). Number of cloves was highest in GN14-05 (22.15) and minimum was observed in GN14-27(16.22). The cultivar GN14-05 recorded the highest marketable yield of 102.6 q/ha, followed by Ooty 1 with 99.5 q/ha and GN14-07 with 80.7 q/ha. It is concluded that, the cultivar GN14-05 was found to be the best for high yield and suitable for Nilgiris conditions.

P42

Essential oil composition of betelvine hybrid and its parents Sirugamani 1 and Swarna Kapoori

K Hima Bindu*, R Ramakrishnan, M A Suryanarayana, K S Shivashankara[1],
Tapas Kumar Roy[1]& T Vasantha Kumar

Section of Medicinal Crops,
[1]Division of Physiology & Biochemistry,
ICAR-Indian Instituteof Horticultural Research, Bengaluru-560089, Karnataka
*bindu@iihr.ernet.in

Betelvine (*Piper betle* L.) is an important commercial crop whose fresh leaves are used as masticator along with additives. The essential oil from freshly harvested leaves extracted through hydro-distillation was analyzed by GC-MS/MS in betelvine hybrid, PBH 06-1 along with female parent, Sirugamani 1 and male parent, Swarna Kapoori. Assessment of constituents of essential oil revealed twenty eight compounds belonging to monoterpenes, oxygenated monoterpenes, phenylpropanoids, sesquiterpenes and oxygenated sesquiterpenes. The percentage of most predominant groups of compounds in female parent, male parent and hybrid, respectively were phenylpropanoids (64.6, 71.37, 53.5), sesquiterpenes (26.74, 15.67, 30.8) and monoterpenes (2.26, 4.66, 6.5). Eugenols, isoeugenol, eugenol acetate, caryophyllene, β-elemene, α-pinene, sabinene and α-terpineol were the major compounds. Anethole and chavicol were not detected in male parent whereas; *β*-pinene was absent in female parent but, all were present in the hybrid. Palustrol, *T.*-cadinol, ĩ-cadinene were not recorded in both parents as well as in the hybrid. The essential oil analysis of hybrid clearly indicated

that, chemical constituents of oil were contributed by both the parents. The monoterpenes (6.5%) and sesquiterpenes (30.8%) were higher and phenypropanoid was less (53.5%) in hybrid compared to parents. The study showed that, variation can be created in quality of essential oil through hybridization and possibility of selection of hybrids with desirable oil composition with higher therapeutic potential.

P43

Diversity studies in (L.) *Plumbago zeylanica*

G Saraswathy, L Nalina*, K Rajamani & A John Joel

Department of Medicinal & Aromatic Crops,
Horticultural College& Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*lnalina_hort@rediffmail.com

An investigation was carried out on *Plumbago zeylanica*(L.) with forty five accessions in the Department of Medicinal and Aromatic Crops, Horticultural College and Research Institute, TNAU, Coimbatore during 2014 - 2015 to study the extent of variability and genetic divergence for morphological, yield and quality traits. The accessions *Pz* 28 and *Pz* 40 recorded highest dry root weight (173.95 g and 113.68 g, respectively) and plumbagin content (0.43% and 0.39%).The maximum phenotypic and genotypic coefficient of variation was observed for harvest index, dry matter production, fresh root weight and plant weight. Heritability estimates were higher for plant height, dry matter production, fresh and dry root weight. Correlation studies indicated that, fresh root weight expressed highly significant and positive correlation with dry root weight. Wide diversity existed among the accessions in morphological and yield characters which is beneficial for developing superior varieties through selection or hybridization programme.

P44

Graviola (*Annona muricata* L.), the cancer killer - a potential crop for improvement

R Richard Kennedy* & P Senthilkumar

Regional Research Station, TNAU, Paiyur-635112, Krishnagiri, Tamil Nadu
*richkenn2006@yahoo.co.in

Graviola (*Annona muricata* L.) is a popular fruit tree that is cultivated throughout the tropical regions of the world. It is a common plant in the house compounds of southern peninsular India. Intensive chemical investigations of the leaves and seeds of this species have resulted in the isolation of a great number of acetogenins. The isolated compounds display some of the interesting biological or the pharmacological activities, such as antitumoral, cytotoxicity, antiparasitic and pesticidal properties. Roots of this species are used in traditional medicine due to their antiparasitical and pesticidal properties. The extract of the plant parts is effective against 12 types of cancer and it is 10000 times powerful than chemotherapy. The greatest advantage with graviola is that, it selectively hunts only the cancer cells, but not the healthy cells. Studies conducted in and around Kanyakumari district revealed

that, a wide variation existed among the types studied. The variability existing in biometrical observations such as plant height, leaf length, leaf width, fruit length, fruit width, fruit weight, TSS (18–26°Brix), number of seeds/fruit, numberof fruits/tree and yield/tree was documented. The average yield in terms of number of fruits/tree was 25-35 with fruit weight of 2-4 kg, which offers great scope for improvement of the crop by selection. The fruit colour ranged from greenish yellow to lemon yellow and the leaf colour varied from yellowish green to dark green. Based on the intensive evaluation, 10 promising types were identified for further evaluation and selection.

P45

Evaluation of Rosemary accessions (*Rosemarinus officinalis)* suitable for Nilgiris

A Sankari, M Anand, S Karthikeyan, N Selvaraj & B Anita*

Horticulture Research Station, TNAU, Ooty-641001, Tamil Nadu
*hrsooty@tnau.ac.in

An experiment was conducted to evaluate accessions of rosemary for herbage yield and oil content. Among the accessions evaluated, the highest plant height was observed in Acc. 5 which recorded 62 cm, followed by Acc. 4 (50 cm) and the lowest was recorded in Acc. 1 (28.92). The leaf length was maximum in Acc. 5 (3.2 cm) compared to Acc. 1 (2.63 cm) which was on par with Acc. 3. The leaf width was maximum in Acc. 1 (0.38 cm), followed by Acc. 5 (0.2 cm). The green leaf yield was maximum in Acc. 5 (618.5 g/plant/year) and 12.37 tonnes/ha compared to local type which recorded, 415 g/plant/year and 8.3 tonnes/ha. The maximum oil content was recorded in Acc. 5 (0.9%), followed by Acc. 1 (0.8%), which was on par with Acc. 4 and local variety. Among the five accessions, Acc. 5 was found superior to the local type with the advantages of high yield potential of 12.37 t/ha of green leaves per year, which was 46% higher than the local type (8.3 t/ha).

Session II

Soil & Plant Health Management

Lead Lectures

L7

Good agricultural practices in medicinal plants

Jitendra Kumar* & R S Jat

Directorate of Medicinal & Aromatic Plants Research, Anand-387310, Gujarat
*director.dmapr@icar.gov.in

The medicinal plants based industry is growing atthe rate of 7-15% annually. According to a conservative estimate, the value ofmedicinal plants related trade in India is to the tune of about Rs 5,000 crores per annum while the world trade is about 62 billion US dollars and is expected to grow tothe tune of 5 trillion US dollars by the year 2050. Besides this, medicinal and aromatic plants (MAP) have substantially contributed to the primary health care of human population across the globe. They are also a significant source of livelihood for many rural communities' especially forest-dwellers, landless poor and marginalized farmers besides their role in prevention as well as curing of human health problems. In spite of scope, importance and awareness and several scientific innovations in the field of MAP, still more than half of the global population does not have access to the primary health care facilities. The major drawback in global market of Indian medicinal plants products are; inconsistent quality, dearth of scientific validity of claimed medicinal properties and high price of the products. Thus, future of medicinal plants sector will depend on continuous supply of quality raw materialuncontaminated by either synthetic pesticides or by genetically modified organisms and certified by accredited agencies. Several reports have showed a number of cases in which consumers have suffered from adverse health effects due to contaminated or adulterated medicinal plant material which certainly raised an issue of safety and quality assurance. The growing demand for herbal medicines has also led to concerns about the environmental impact of large-scale commercial collection from the wild. Many valuable medicinal plant species have become threatened, rare or even endangered due to over-exploitation from their natural habitat. Due to these concerns many countries aremonitoring the medicinal plants quality in trade and formulated regulatory standards to check the quality at the primary stages of production which ultimately determining the quality of the end product. These guidelines are known as Good Agricultural and Collection Practices (GACP).GACP for medicinal plants are a set of guidelines for farmers and collectors on how to produce high quality raw materials for the herbal medicine industry. Another intentionto develop GACP was that, the cultivation of medicinal plants is a highly localized occupation and displays a lot of variability in cultural practices and varietal preferences across regions which reflect product variability. It is, therefore, necessary to define and assign certain common location specific minimum standards to facilitate production of these products. Thus, such standards envisaging focused approach for implementing Good Agricultural Practices (GAP), traceability *etc.* through appropriate infrastructure, record keeping and monitoring would reap following broad benefits:

- Build up culture for good agricultural practices by the farmers,
- Uniform approach across farms regardless of their sizes
- Increased awareness among the farmers as well as the consumers about the need for consumption of good quality produce
- Traceability through complete integration of supply chain
- Improvement in the environment as well as soil fertility
- Worker safety and welfare
- Reputation in the international market as a producer of good quality and safe produce.

With this in view, the World Health Organisation in 2003 has formulated guidelines of good agricultural practices intended for a global audience, covering principles that apply to all medicinal plant producers, from tribal collectors in remote forests to hi-tech farmers in industrialised countries with the objectives to:

- Contribute to the quality assurance of medicinal plant materials used as the source for herbal medicines, which aims to improve the quality, safety and efficacy of finished herbal products;
- Guide the formulation of national and/or regional standards; and
- Encourage and support the sustainable cultivation and collection of medicinal plants of good quality in ways that respect and support the conservation of medicinal plants and the environment in general.

But, these guidelines were not applicable with same principles under diverse environmental and social conditions throughout the world hence, it was suggested that country or region-specific standards can be developed that are targeted specifically towards the farmers and collectors of that area. In India, the National Medicinal Plants Board, in collaboration with the WHO Country Office for India, developed a set of guidelines and standards for Good Agricultural Practices (GAP) and Good Field Collection Practices (GFCP) in 2009. These guidelines and standards targeted specifically towards medicinal plant producers in the Indian subcontinent. Besides India, region specific GAPs were developed by China (2002), European Union (2002) and Japan 2003). Other guidelines relevant to medicinal plants are *Codex Alimentarius, Code of Practices* developed by the Joint FAO/WHO Codex Alimentarius Commission.

Good Agricultural Practices can be summarized as: clean soil, clean water, clean hands and clean surfaces. These principles must be applied to each phase of production (field selection, pre-plant field preparations, production, harvest and post-harvest).

Principles of good agricultural practices

Identification/authentication of cultivated medicinal plants

Selection of medicinal plants

The species or botanical variety selected for cultivation should be the same as that specified in the national pharmacopoeia or recommended by other authoritative national documents of the end-user's country. In the absence of such national documents, the pharmacopoeia or other authoritative documents of other countries should be considered. In the case of newly introduced medicinal plants, the species or botanical variety selected for cultivation should be identified and documented as the source material used or described in traditional medicine of the original country.

Botanical identity

The botanical identity – scientific name (genus, species, sub-species/variety, author and family) of each medicinal plant under cultivation should be verified and recorded. If available, the local and English common names should also be recorded. Other relevant information, such as the cultivar name, ecotype, chemotype or phenotype, may also be provided, as appropriate. For commercially available cultivars, the name of the cultivar and of the supplier should be provided. In the case of landraces collected, propagated, disseminated and grown in a specific region, records should be kept of the locally named line, including the origin of the source seeds, plants or propagation materials.

Seeds and other propagation materials

Planting material plays an important role in the production of horticulturalcrops. Inadequate availability of quality planting material is one of the importantdeterring factors in development of a sound horticulture industry. At present 30-40%demand for planting material is being met by the existing infrastructure. Farmers do nothave access to certified disease free material as a result of which production, productivity and quality of the produce suffers. Much of the dependence is on theunregulated and unmonitored private sector in most of the states. The existingnurseries lack modern infrastructure such as greenhouses, mist chambers, efficientnursery tools and gadgets, implements and machinery. The seeds and other propagation materials should be specified and suppliers of seeds and other propagation materials should provide all necessary information relating to the identity, quality and performance of their products, as well as their breeding history, where possible. The propagation or planting materials should be of the appropriate quality and be as free as possible from contamination and diseases in order to promote healthy plant growth. Seeds and other propagation materials used for organic production should be certified as being organicallyderived. Counterfeit, substandard and adulterated propagation materials must be avoided.

Cultivation

Though economic importance of medicinal plants is well known, it is considered as a forestry sub-sector (non-timber forest products) in India. Recognizing and addressing the needs of each of the stakeholders involved requires a holistic approach for over all development of the medicinal and aromatic plants sector. Several studies have clearly brought out the economic potential of medicinal plants in different agro-climatic conditions. The potential return to the farmers from cultivation of medicinal plants is reported to be quite high in case of certain high altitude Himalayan herbs. The success story on cultivation of opium poppy in Rajasthan & M.P., isabgol cultivation in Gujarat, Rajasthan and M.P., senna cultivation in Rajasthan, mentha cultivation in U.P., palmarosa cultivation in central India, jasmine cultivation in south India and saffron cultivation in Kashmir are well known. However, more research is needed for proper planning for cultivation and utilization of medicinal plants with modern science and technological interventions keeping in view their ecological and aesthetic values. The following science led technological interventions are suggested to make the medicinal and aromatic plants more productive and profitable enterprise.

The cultivation practices vary depending on the agro-climatic conditions and species. If no scientific published or documented cultivation data are available, traditional methods of cultivation should be followed, where feasible. Otherwise a method should be developed through research. The principles of good plant husbandry, including appropriate rotation of plants selected according to environmental suitability, should be followed and tillage should be adapted to plant growth and other requirements.Conservation Agriculture (CA) techniques should be followed where appropriate, especially in the build-up of organic matter and conservation of soil humidity.

Site selection

Medicinal plant of same species can show significant differences in quality when cultivated at different sites, owing to the influence of soil, climate and other factors. These differences may relate to physical appearance or to variations in their constituents. Thus, medicinal plant species of a specific region should be grown in the similar agro-climatic conditions for better quality and yield. Risks of contamination as a result of pollution of the soil, air or water by hazardous chemicals should be avoided.

Irrigation and drainage

Irrigation and drainage should be controlled and carried out in accordance with the needs of the individual medicinal plant species during its various stages of growth. Water used for irrigation purposes should comply with local, regional and/or national quality standards. Care should be exercised to ensure that the plants under cultivation are neither over- nor under-watered.

Plant maintenance and protection

The growth and development characteristics of individual medicinal plants, as well as the plant part destined for medicinal use, should guide field management practices. The timely application of measures such as topping, bud nipping, pruning and shading may be used to control the growth and development of the plant, thereby improving the quality and quantity of the medicinal plant material being produced.

Any agrochemicals used to promote the growth of or to protect medicinal plants should be kept to a minimum and applied only when no alternative measures are available. Integrated pest management should be followed where appropriate. When necessary, only approved pesticides and herbicides should be applied at the minimum effective level, in accordance with the labelling and/or package insert instructions of the individual product and the regulatory requirements that apply for the grower. Growers and producers should comply with maximum pesticide and herbicide residue limits, as stipulated by local, regional and/or national regulatory authorities of both the growers' and the countries and/or regions. International agreements such as the International Plant Protection Convention5 and Codex Alimentarius should also be consulted on pesticide use and residues.

Harvest and post-harvest

Medicinal plants should be harvested during the optimal season or time period to ensure the best quality production of medicinal plant materials and finished herbal products. The best time for harvest (quality peak season/time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts. During harvest, care should be taken to ensure that no foreignmatter, weeds or toxic plants are mixed with the harvested medicinal plant materials. Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity. The harvested material should be kept in dry and lean places. The harvested raw medicinal plant materials should be transported promptly under clean,dry conditions.

Personnel

Growers and producers should have adequate knowledge of handling the medicinal plant concerned. All personnel (including field workers) involved in the propagation, cultivation, harvest and post-harvest processing stages of medicinal plant production should maintain appropriate personal hygiene and should have received training regarding their hygiene responsibilities. Visitors to processing and handling areas should wear appropriate protective clothing and adhere to all the personal hygiene provisions mentioned above.

Quality assurance

Compliance with quality assurance measures should be verified through regular auditing visits to cultivation or collection sites and processing facilities by expert representatives of producers and buyers and through inspection by national and/or local regulatoryauthorities.

Documentation

Standard operating procedures should be adopted and documented. All processes and procedures involved in the production of medicinal plant materials and the dates on which they are carried out should be documented. The types of information that should be collected include:

- seeds and other propagation materials
- cultivation or collection site history
- Sowing or planting
- crop rotation history at the site
- use of manures, compost, fertilizers, growth regulators, pesticides and herbicides
- unusual circumstances that may influence the quality (including chemical composition) of the medicinal plant materials (e.g. extreme weather conditions, exposure to hazardous substances and other contaminants, or pest outbreaks)
- harvest or collection
- all processing during post-harvest
- transportation
- storage conditions
- personnel involved
- A photographic record (including film, video, or digital images) of the cultivation or collection site and the medicinal plants under cultivation or collection should be made, whenever possible.
- All agreements between the grower or collector, processor and purchaser and intellectualproperty and benefit-sharing agreements should be recorded.
- Batch numbers should unambiguously and clearly identify all batches from eachcultivation or collection area.

Good collection practices for medicinal plants

The collection practices should ensure the longterm sustainability of wild populations and their associated habitats. Management plans for collection should provide a framework for setting sustainable harvest levels and describe appropriate collection practices that are suitable for each medicinal plant species and plant part used (roots, leaves, fruits, *etc.*). Collection of medicinal plants raises a number of complex environmental and social issues that must be addressed locally on a case-by-case basis. It is acknowledged that these issues vary widely from region to region and cannot be fully covered by these guidelines.

Permission to collect

The collectors should get collection permits and other documents from government authorities and landowners prior to collecting any plants from the wild.

Selection of medicinal plants for collection

The species or botanical variety selected for collection should be the same as that specified in the national pharmacopoeia or recommended by other authoritative national documents.

Collection

The population density of the target species at the collection site(s) should be determined and species that are rare or scarce should not be collected. To encourage the regeneration of source medicinal plant materials, a sound demographic structure of the population has to be ensured. Medicinal plant materials should be collected during the appropriate season or time period to ensure the best possible quality of both source materials and finished products. Only ecologically non-destructive systems of collection should be employed. Medicinal plants should not be collected in or near areas where high levels of pesticides or other possible contaminants are used or found, such as roadsides, drainage ditches, mine tailings, garbage dumps and industrial facilities which may produce toxic emissions. After collection, the raw medicinal plant materials may be subjected to appropriate preliminary processing, including elimination of undesirable materials and contaminants, washing (to remove excess soil), sorting and cutting.

Cultivation through integrated approach

There are only few MAP spp. like opium poppy, isabgol, mentha, palmarosa whose cultivation is undertaken as sole crop and is profitable. Even under such situation also, the farmers should always use improved cultivation practices and should ensure the efficient use of monetary and non-monetary inputs so that per unit cost of production is minimum. The R&D institutions have already developed the improved production and processing technologies for these crops. On the other hand, under the situation of declining land and water resources, sole cropping of MAP is no longer possible and unprofitable also. There is alternative to grow these crops as an inter-crop, catch crop, border crop with agricultural and horticultural crops in an integrated manner. The forestry sector has a vast potential of growing of MAP. The integrated cropping system approach will always will be profitable and will also have low risk factor and the grower will get an additional income from thesesystems.Integrated nutrient management (INM) for sustaining the desired crop productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner and integrated pest management (IPM) aims at judicious use of cultural, biological, chemical, host plant resistance/tolerance, physical-mechanical control and regulatory control methods should be employed in the cultivation of MAP and ensuring the guidelines of GAP for high quality standardsand to minimize the risk of pesticide residues in fresh and processed produce.

Conclusion

A national and/or regional inventory on distribution, abundance and threats of medicinal plants may facilitate the future harvest of medicinal plants. It can also be used as a tool in tackling questions concerning intellectual property rights issues. Research is greatly needed to improve the agronomy of cultivated medicinal plants, promote the exchange of information on agricultural production and investigate the social and environmental impact of medicinal plant cultivation and collection. Data sheets and monographs should be developed on medicinal plants that take intoaccount the particular situation of regions and countries. Large scale trainings should be organized to create awareness and dissemination of technologies on good agricultural and collection practices is prime important for production of quality raw drugs, their certification and premium price.

L8

Sustainable plant protection technologies in spice crops

S Devasahayam*, R Suseela Bhai & Santhosh J Eapen

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*devasahayam@spices.res.in

Infestation by pests and pathogens coupled with poor plant health is one of the major factors for the low productivity of spice crops like black pepper (*Piper nigrum*), cardamom (*Elettariacardamomum*), ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) in India. Intensive use of spice crop agro-ecosystems to enhance productivity can also affect the health of these crops. Hence, adoption of sustainable management schedules integrating a wide range of practices for control of pests and pathogens is important. The advances in sustainable crop protection technologies targeting pests and pathogens of spice crops, involving cultural and biological means, use of resistant varieties and plant products and need-based application of pesticides are highlighted in this chapter.

Black pepper

Phytophthora foot rot

Phytophthora foot rot caused by *P. capsici*which affects all parts of the vine is the most devastating disease of black pepper in India. The disease is common during the monsoon season and high soil moisture, rainfall and humidity are conducive for the spread of the disease. The entire vine wilts followed by shedding of leaves and spikes when the main stem at the collar region is infected. The expression of symptoms is delayed till cessation of rain when the infection is confined to the feeder roots and the vine exhibits foliar yellowing, wilting and defoliation. Such vines may recover after the onset of rains and survive for more than one or two seasons till the root infection culminates in collar rot and death of the vine.

Management

The strategies developed for the management of the disease include, raising black pepper cuttings in solarized soil fortified with biocontrol agents, planting healthy cuttings in the field, removal of dead vines along with the root system, shade regulation with the receipt of pre-monsoon showers and providing adequate drainage in the plantation. In severely disease affected areas, IISR-Shakthi which is resistant to the disease may be planted. Antagonistic microorganisms such as *Trichoderma harzianum* may be applied around the base of the vine @50 g/ vine (10^8 cfu/g) with the onset of monsoon during May-June and also during August-September (in Kerala). Addition of organic mulches improves the texture of soil and enhances the growth of antagonistic microorganisms. Prophylactic spraying with Bordeaux mixture (1%) and drenching with copper oxychloride (0.2%) should also be undertaken during May-June and August-September. Alternatively, spraying and drenching with potassium phosphonate (0.3%) or metalaxyl-mancozeb (1.25 g/L) during May-June and August-September may be undertaken; in case biocontrol agents are applied, drenching may be avoided.

Slow decline

Slow decline which is a widespread disease in black pepper areas, is caused by the association of root knot nematodes (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis*) and also *P. capsici*.

The affected vines exhibit foliar yellowing initially and with depletion of soil moisture during the post monsoon season, they exhibit defoliation and die-back and finally death of the vine. Vines infested with *M. incognita* exhibit inter-veinal chlorosis and galling in roots; *R. similis* causes necrotic lesions on feeder roots which lead to disintegration of distal portion of the roots.

Management

Use of nematode-free planting material, de-nematization of nursery mixture by solarization or fumigation with chemicals and fortification with biocontrol agents are important. In the field, uprooting and destruction of diseased vines along with the roots and exclusion of susceptible intercrops and support trees can minimize nematode infestations. 'Pournami', which is resistant to *M. incognita,* may be cultivated in root-knot nematode infested areas. Application of antagonistic fungi, such as *Pochonia chlamydosporia* and *Trichoderma harzianum* around base of the vine @50 g/vine (10^8 cfu/g) with the onset of the monsoon during May-June and also during August-September is recommended. As a preventive measure, planting materials can be treated with 1 g phorate 10G or 3 g of carbofuran 3G per plant (banned in Kerala) or 0.025% carbosulfan. In plantations, application of 100 g of carbofuran 3G or 30 g of phorate 10G per vine during May-June and again in August-September may be undertaken when the infestation is severe.

Pollu beetle

The *pollu* beetle (*Lanka ramakrishnai*) is the most destructive insect pest of black pepper in the plains and midlands in India. The adult beetle feeds on tender shoots, leaves and spikes resulting in black patches on tender shoots and spikes and small irregular circular holes on tender leaves. The larva (grub) bores into tender spikes and berries and feed on the internal contents. The infested spikes develop necrotic patches and the berries turn black and crumble when pressed. The pest infestation is higher in heavily shaded areas in plantations.

Management

Regulation of shade in the plantation by lopping-off branches of support and shade trees with the onset of pre-monsoon rains helps in reducing the build-up of pest population. Spraying the vines during July and October with quinalphos (0.05%) or spraying quinalphos (0.05%) during July followed by Neemgold 0.6% (neem product) during August, September and October, may be undertaken.

Scale insects

Scale insects such as mussel scale (*Lepidosaphespiperis*) and coconut scale (*Aspidiotusdestructor*) are serious insect pests of black pepper at higher altitudes. The mussel scale encrusts main stems, lateral branches, mature leaves and berries resulting in chlorotic patches, yellowing and drying of leaves and mortality of young vines. The infested branches wilt and dry resulting in vacant spaces in the canopy. The coconut scale infests mature leaves resulting in chlorotic patches and sometimes also infests berries. The pest infestation is higher during the post monsoon and summer months. *A. destructor* also infests many other economically important crops in India.

Management

Predatory beetles such as *Chilocorus*spp. and*Pseudoscymnus* spp. and parasitoids such as *Aphytis* sp. and *Encarsia* spp. are major natural enemies of scale insects and are to be conserved. Natural products such as neem oil (0.3%) or Neemgold (0.3%) or fish oil rosin (3%) are effective for the management of scale insects during initial stages of infestation. In case the infestation is severe, spraying of dimethoate (0.1%) may be undertaken selectively on affected vines after clipping off severely infested branches after harvest of berries; the spraying may have be repeated after 21 days if the infestation persists.

Emerging pests and diseases

Viral diseases

Stunt disease caused by *Cucumber mosaic virus* (CMV) and *Piper yellow mottlevirus* (PYMoV) is becoming serious in recent years especially at high altitudes. The diseased vines exhibit shortening of internodes and the leaves become narrow, puckered and crinkled; chlorotic spots and streaks also appear on the leaves. The mealybugs *Ferrisia virgata* and *Planococcus citri*, transmit PYMoV; CMV is transmitted by aphids.

Virus-free cuttings are to be used for propagation under insect-proof conditions and planting in the field. Regular monitoring of the nursery and field for insect vectors bugs is important which may be controlled with dimethoate (0.05%). Regular inspection and removal of infected plants and replanting with healthy plants should be resorted to in the field. Other weed and crop hosts, which may act as reservoirs for the virus also need to be removed and destroyed.

Anthracnose

Anthracnose or *pollu* disease caused by *Colletotrichum* spp. is increasingly becoming serious at high altitudes. The symptoms of the disease include appearance of small, black spots surrounded by a halo on the leaves, crinkling of leaf lamina and blackening of berries. The disease when combined with heavy shade, lack of pollination and delayed emergence of spikes, results in large scale spike shedding.

Irrigation of vines 4-5 times at an interval of 5-7 days commencing from the third week of March, followed by shade regulation of support trees is effective for managing spike shedding.Phytosanitation, spraying with carbendazim-mancozeb (0.1%) and nutrition management are important for holistic management of the disease.

Root mealybugs

Infestation by root mealybugs (*Planococcus* spp.) is more common at higher altitudes especially in Wayanad (Kerala) and Kodagu (Karnataka) districts and is more severe on vines affected with *Phytophthora* sp. and nematodes. Colonies of root mealybugs are observed at the basal portion of the stem under the soil and on roots causing yellowing, wilting and mortality of vines.

Root mealybugs can be managed by planting pest-free cuttings, removal of weeds in the interspaces of black pepper vines during summer and drenching tobacco extract (2%) in mild infestations or chlorpyriphos (0.075%) when the infestation is severe and also by undertaking management schedules against *Phytophthora* and nematodes.

C**ardamom**

Capsule rot

Capsule rot caused by *Phytophthora meadii* is widespread in Wayanad and Idukki districts in Kerala, especially during the monsoon season. The initial symptoms of infection include appearance of water soaked lesions on young leaves and capsules which enlarge to cover the entire surface area; the infected capsules turn dull green and later rot and are shed from the panicle. The infection is pre-disposed by thick shade, close spacing of plants, high soil moisture and water logging.

Management

Dried leaves and mulch should be removed prior to the onset of monsoon. Shade regulation and adequate drainage should also be provided in the field. Biocontrol agents such as *Trichodermaharzianum* (50 g/clump) (10^8 cfu/g), multiplied in decomposed coffee compost and mixed with cow dung may be applied during May-June and August–September. A prophylactic spray with Bordeaux mixture (1%) and drenching with copper oxychloride (0.2%) may be undertaken during May-June and August-September; in case biocontrol agents are applied, drenching may be avoided. Alternatively, spraying and drenching with potassium phosphonate (0.3%) or metalaxyl-mancozeb (1.25 g/L)may be undertaken.

Rhizome rot

The disease is observed in nurseries and plantations during the monsoon season and is caused by soil-borne fungi such as *Pythium vexans* and *Rhizoctonia solani*. In the nursery, the disease is expressed as dark brown discolouration at the collar region of the seedling. The roots and rhizomes of affected plants rot and the leaves become flaccid and may later wilt and dry. In the field, rotting starts at the collar region and extends to the rhizomes and roots and the foliage of infected plants turn yellow; the affected tillers breaks off easily and may fall.

Management

Removal of dried leaves and mulch should be done prior to the onset of monsoon. Shade regulation and adequate drainage should also be provided in the field. The resistant variety IISR-Avinash may be planted in severely disease affected areas. Biocontrol agents such as *Trichodermaharzianum* (50 g/clump) (10^8 cfu/g), multiplied in decomposed coffee compost and mixed with cow dung may be applied during May-June and August–September. A prophylactic drenching with copper oxychloride (0.25%) and spraying with Bordeaux mixture (1%) may be undertaken during May-June and August-September; in case biocontrol agents are applied, drenching with copper oxychloride may be avoided. Alternatively, potassium phosphonate (0.3%) or metalaxyl-mancozeb (1.25 g/L) may be drenched and sprayed.

Viral diseases

The viral diseases affecting cardamom include mosaic (*katte*) and vein-clearing (*kokke kandu*) diseases. The symptoms of mosaic disease appears on the youngest leaf as slender chlorotic flecks which later develop into pale green discontinuous stripes running parallel on the emerging leaves. In advanced stages, the affected plants produce shorter and slender tillers with few short panicles. In plants affected with vein-clearing disease, the leaves exhibit intra-veinal clearing, stunting, loosening of leaf sheath and shredding of leaves. The new leaves of affected plants get entangled in the older leaves and form hook-like tiller. Light green patches with shallow grooves are seen on immature capsules; cracking of capsules is also observed. Both the diseases are transmitted through the aphid*Pentaloniacaladii* and *P. nigronervosa.*

Management

Use of virus-free planting material, removal of infected plants and weeds and alternative hosts which might act as reservoirs for the virus and multiplication of the vector should be undertaken regularly.

Aphid vectors may be controlled by spraying botanicals. The *katte* resistant variety IISR Vijetha may be cultivated in severely disease affected areas.

Root-knot nematodes

Plant parasitic nematodes such as *M. incognita* and *M. javanica* cause considerable damage to feeder roots of cardamom in nurseries and plantations. Heavily infested plants exhibit stunting, reduced tillering, reduced leaf size, yellowing of foliage, immature capsule drop and increased incidence of rhizome rot. In the nursery, nematode infestations are responsible for pre-emergence failure in primary seed beds and reduced production of standard seedlings in secondary nursery.

Management

Disinfecting nursery beds with a suitable fumigant under polythene cover for 3–7 days or application of phorate 10G @30–40 g/sq. m or carbofuran 3G @40-50g/sq. m. (banned in Kerala) help in reducing nematode populations. In plantations, planting of nematode-free seedlings, application of organic manures and neem oil cake twice a year @250–1000 g and spot application of carbofuran 3G or phorate 10G 15–50 g, during May-June and August-September helps to reduce nematode populations.

Cardamom thrips

The cardamom thrips (*Sciothrips cardamomi*) is the most destructive insect pest of cardamom. The adults and larvae lacerate the tissues of leaves, shoots, panicles, flowers and immature capsules and feed on the exuding sap resulting in shedding of flowers and immature capsules and scab formation on mature capsules. The infested capsules lose their aroma and the formation of seeds is also affected. The pest population builds up rapidly during the post monsoon and summer months and declines with the onset of rains. The pest infestation is higher in thickly shaded areas in the plantation.

Management

Regulation of shade in the plantation by pruning branches of shade trees and removal of alternate host plants in the vicinity of plantations helps in reducing the build-up of pest population in the field. Removal of dried leaf sheaths during February-March and spraying 5–7 rounds of quinalphos (0.025%) orfipronil (0.005%)or spinosad (0.0135%)(natural product) during March, April, May, August and September (avoiding periods of high honeybee activity) may be undertaken for controlling the pest infestation. The entomopathogenic fungus *Lecanicillium psalliotae* is also promising for the management of cardamom thrips.

Shoot and capsule borer

The shoot and capsule borer (*Conogethes punctiferalis*) is a serious insect pest in nurseries and plantations. The earlier stages of larvae bore into panicles and immature capsules and the later stages bore into pseudostems and feed on the internal tissues. The presence of bore holes with extruding frass on the pseudostems and capsules and the withered central shoot are characteristic symptoms of the pest infestation. The pest infestation is higher during shoot, panicle and capsule formation stages. The shoot borer is highly polyphagous and has been recorded on several economically important plants in India.

Management

Removal and destruction of alternate host plants in and around cardamom plantations, removal of infested suckers as indicated by extrusion of frass, during September-October when the infestation is less than 10%, collection and destruction of adults and conservation of natural enemies (parasitoids) such as *Eriborus trocheanteratus*, *Xanthopimplaaustralis*, *Friona* sp. and *Agrypone* sp. help in reducing the pest infestation. In case the infestation is severe, spraying of quinalphos (0.075%) twice, during January-February and September-October may be undertaken.

Root grub

The root grub (*Basilepta fulvicorne*) is a serious insect pest in nurseries and plantations. The larvae feed on roots and rhizomes and in severe cases of infestation, the entire root system is eaten away. The infested plants turn yellow and become stunted; severally infested young plants and seedlings, succumb to the pest attack. Seedlings and young plants damaged by the root grub are subsequently infected by secondary pathogens resulting in rotting. The adults emerge in large numbers from earthen cocoons after the receipt of showers during April-May and September-October. The adults are polyphagous and feed on a number of trees in and around cardamom plantations.

Management

Collection and destruction of adult beetles during peak periods of emergence during April-May after summer showers is effective in reducing the pest population in the field. Along with collection of adults, application of phorate 10G @20–40 g/clump (banned in Kerala) or chlorpyriphos (0.075%) during May–June and September–October synchronizing with the egg laying period is effective for the management of the pest. The entomogenous fungi,*Metarrhizium anisopliae* and *Beauvaria bassiana* and the entomophagus nematode,*Heterorhabditis* sp. play an important role in reducing the population of the pest in the field.

Emerging pests and diseases

Leaf blight

In recent years, leaf blight caused by foliar infections of *Colletotrichum* spp. is becoming serious especially during the monsoon and post-monsoon periods. The symptoms develop as brownish spots and patches on the leaf lamina which expand and the affected leaves wither and dry. The disease can be controlled by foliar spraying with hexaconazole (0.1%) and soil application of *T. harzianum*.

Whitefly

The cardamom whitefly (*Dialeurodes cardamomi*) is becoming a serious insect pest in Kerala and Tamil Nadu especially during the dry summer seasons. The adults and nymphs occur on the lower leaf surface and they suck the sap resulting in yellowing and drying of leaves and affecting the vigour of plants. Setting up of yellow sticky traps, conservation of natural enemies and spraying neem oil (5%), are effective in controlling the pest.

Shoot fly

The larva of shoot fly (*Formosina flavipes*) feed on the growing shoot of young cardamom plants resulting in formation of dead hearts. The pest incidence is generally severe during the post monsoon period and young plants in new plantations with inadequate shade are seriously affected. Early planting, provision of sufficient shade, removal and destruction of affected shoots with maggots and drenching dimethoate or quinalphos (0.05% each) are effective for the management of the pest.

Ginger and Turmeric

Rhizome rot

Rhizome rot or soft rot caused by *Pythium* spp. is the most destructive disease of ginger and turmeric. The fungus multiplies in the soil with build-up of soil moisture with the onset of the monsoon and younger sprouts are highly susceptible to the pathogen. The infection starts at the collar region of the pseudostem as water soaked lesions and the rotting spreads to the rhizome and root. During early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. The yellowing spreads to all leaves followed by withering and drying and the infected pseudostems can be pulled out easily.

Management

Seed rhizomes are to be selected from disease-free gardens, treated with mancozeb (0.3%) and stored suitably. Selection of well drained soils for planting is important and the soil of the selected area should be solarized by covering the moist soil with a transparent polythene film for 40-45 days. Biocontrol agents such as *Trichoderma harzianum* along with neem cake @50 g kg / bed of 3 × 1 m (10^8 cfu/g) should be applied at the time of planting and after 45 days. Removal of affected clumps and drenching the affected and surrounding beds with copper oxychloride (0.2%) or metalaxyl-mancozeb (1.25 g/L) checks the spread of the disease.

Bacterial wilt

Bacterial wilt is a soil and seed-borne disease occurring on ginger during the monsoon period and is caused by *Ralstonia solanacearum*. The initial symptoms of the disease include appearance of water soaked spots at the collar region of the pseudostem which spreads upwards and downwards. Later mild drooping and curling of leaf margins and yellowing of the lower leaves are observed which spread upwards. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms and the rhizomes ultimately rot. The affected pseudostem and rhizome extrudes milky ooze when pressed gently.

Management

Seed rhizomes are to be selected from disease-free gardens and stored suitably. Selection of well drained soils for planting is important and fields used for growing solanaceous crops such as brinjal, tomato, *etc*. should be avoided. In endemic areas crop rotation with non-host plants like cereals can be adopted. The soil of the selected area can be solarized by covering the moist soil with a transparent polythene film for 40–45 days. Strict phyto-sanitation including use of contaminated tools and irrigation water should be avoided. Removal of affected plants and drenching the surrounding beds with copper oxychloride (0.2%) arrests the spread of the disease.

Nematodes

Root-knot (*Meloidogyne* spp.), burrowing (*R. similis)* and lesion (*Pratylenchus* spp.) nematodes are important nematode pests of ginger and turmeric. Stunting, chlorosis, poor tillering and necrosis of leaves are the common aerial symptoms. Root galls and lesions that lead to rotting are generally seen in infested roots. The infested rhizomes exhibit brown, water soaked areas in the outer tissues. Nematode infestation also aggravates rhizome rot disease in ginger and turmeric.

Management

Nematode infestations can be controlled by using nematode-free seed rhizomes, treating the infested rhizomes with hot water (50°C) for 10 minutes and solarizing ginger and turmeric beds prior to planting. If the infestation is severe application of carbofuran @3 kg a.i. / ha (banned in Kerala) is advocated. In areas where root-knot nematode population is high, the resistant variety of ginger IISR-Mahima may be cultivated.

Shoot borer

The shoot borer *(Conogethes punctiferalis)*is the most serious insect pest of ginger and turmeric. The larvae bore into shoots and feed on the internal tissues resulting in yellowing and drying of infested shoots. The presence of bore-holes on the shoots through which frass is extruded and the withered central shoot is a characteristic symptom of the pest infestation. The shoot borer is highly polyphagous and has been recorded on several economically important plants in India.

Management

An integrated schedule including pruning of freshly infested shoots (as indicated by the extrusion of frass) at fortnightly intervals during July–August and spraying malathion (0.1%) at monthly intervals during September–October is effective in controlling the pest infestation on ginger. In turmeric spraying malathion (0.1%)or lamda-cyhalothrin (0.0125%) at 21 day intervals during July–October is effective. The spraying should be initiated as soon as the first symptom of pest damage is noticed on the tender leaf.

Rhizome scale

The rhizome scale (*Aspidiella hartii*)infests rhizomes of ginger and turmeric in the field (especially at later stages) and storage. The pest infestation appears as encrustations on the rhizomes. The rhizome scale feeds on plant sap leading to shriveling and desiccation of infested rhizomes.

Management

Timely harvest and discarding of severely infested rhizomes before storage reduces further spread of the pest infestation in storage. Dipping of seed rhizome in quinalphos (0.075%) after harvest and storage in dry leaves of *Strychnos nux-vomica* + saw dust in 1:1 proportion is effective in controlling the pest infestation on ginger and turmeric.

Emerging pests

Root grubs

Root grubs (*Holotrichia* spp.) sometimes cause serious damage to ginger plants in north-east India. The grubs feed on roots, newly formed rhizomes and base of pseudostems leading to yellowing of leaves. The entire crop may be lost in severely infested fields. The adults emerge in large numbers with the receipt of summer showers during April-May.

Management

Mechanical collection and destruction of adults during their peak periods of emergence and application of the entomophagous fungus *Metarhizium anisopliae* mixed with fine cow dung is effective for the management of root grubs. However in severely affected areas, mechanical collection and destruction of beetles and drenching with chlorpyriphos (0.075%) may be necessary.

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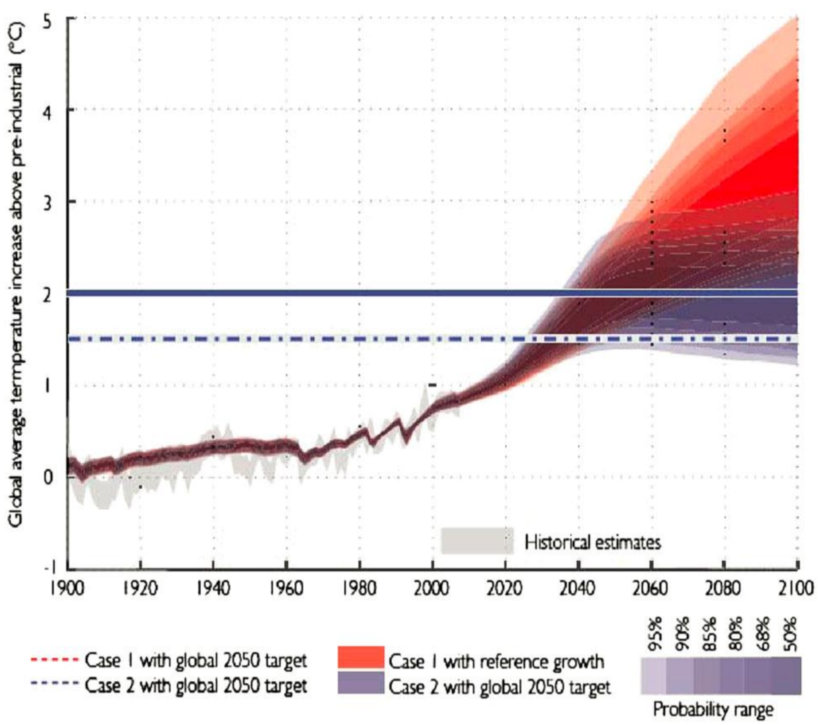
Carbon sequestration in spices cropping systems- future strategies for climate change

E V S Prakasa Rao

Formerly, Head, SCIR-Central Institute of Medicinal & Aromatic Plants, Research Centre and Chief Scientist, CSIR-Centre for Mathematical Modelling & Computer Simulation, Bengaluru
evsprakasarao@gmail.com

Human induced climate changes will have significant impacts on the earth's future. Anthropogenic activities have severely impacted earth systems and scientists are now posed with challenges of devising mitigation and adaptation strategies to minimize the climate induced effects. Based on current projections based on emission scenarios, global warming between 0.3 and 4.8°C is predicted by the end of this century (IPCC 2013; Fig. 1). Such increases in temperatures will adversely impact agricultural production in south Asia and Sub-Saharan Africa (Swaminathan & Kesavan 2012). India is a leading producer of a variety of crops which include spices. India produces more than 5 MT of spices from an area of about 3 m ha (ICAR-IISR 2015). Spice growing regions in India are located in unique ecological conditions which make their future production vulnerable to climate change.Though the eco-systems of spice growing regions are vulnerable, they offer several solutions for climate change mitigation and adaptation. However, so far, such an approach to place and design the role of spice growing regions for climate-smart agriculture has not received desired attention. Therefore, some emerging issues of climate change, carbon emissions and sequestration in spice based cropping systems are discussed in the following sections.

Fig. 1. Effects of the Copenhagen Accord on global average temperature through the 21st century



(**Source:** Rogelj *et al*. 2010)

Climate change, carbon emissions and sequestration

Climate change and increasing concentrations of atmospheric greenhouse gases (GHGs) will not only lead to mean global warming but may also change the frequency and severity of extreme events (IPCC, 2013). CO_2 accounts for 80% of GHGs. Extreme droughts, heat waves, precipitation, storms *etc.* may impact structure and functioning of terrestrial ecosystems and thus carbon cycling and its feedbacks to the climate system. Though most of the global climate models project impacts of GHG emissions on global warming, their feed backs to the climate systems are not understood adequately. As to how climate extremes drive ecological processes and effect carbon cycle needs to be understood completely (Dorothea *et al.* under publication, doi: 10.1111/gcb.12916). Therefore, regional investigations are required to upscale the impacts of climate extremes on global carbon-climate feedbacks. According to IPCC, agriculture is responsible for 10-12% of total global anthropogenic emissions and 24% of the increase in atmospheric GHG emissions. In India, agriculture contributes to about 17% of the CO_2 equivalent emissions for the base year 2007 according to INCCA (Indian Network for Climate Change Assessment 2010). The projected CO_2 concentrations by 2100 would range from 550 to 900 ppm. It is important to make regional assessments to allow global upscaling of the impacts of climate extremes on global carbon-climate feedbacks.There is a lack of systematically collected data and there is a non-linear response of ecosystems to extreme events which make quantitative meta-analysis of climate extremes on the carbon cycle difficult (Vicca *et al.* 2014).

Soils are important in global C cycle (Table 1). Agro-ecosystems will be important in both emissions and capture of CO_2. Therefore, agro-ecosystems such as spice growing regions in tropics will have challenging contributions to C budgets.

Table 1. Global soil carbon fact sheet

Amount of carbon in top 1 m of Earth's soil ; 2/3 as organic matter	2200 Gt
Organic C is around 2 × greater C content than Earth's atmosphere	
Fraction of antecedent soil and vegetation carbon characteristically lost from 60%agricultural land since 19^{th} century	
Fraction of global land area degraded in past 25 years due to soil carbon loss	25%
Rate of soil loss due to conventional agriculture tillage	~1 mm $year^{-1}$
Rate of soil formation	~0.01 mm $year^{-1}$
Rate of peatlands loss due to drainage compared to peat accumulation rate	20 × faster
Equivalent fraction of anthropogenic greenhouse gas emissions from peatland loss	6% annually

Source : (Banwart *et al*. 2014)

Transforming carbon in the air into soil and biomass carbon and long term storage of carbon in the terrestrial biosphere, underground, or the oceans in order to reduce atmospheric CO_2 is one way of addressing climate change. Potential sources of CO_2 emissions from agricultural systems include- N fertilizer production, on farm fossil fuel, livestock related activities, deforestation, cultivated soils and tillage, processing, supply chain operations and packaging, cold chain and transport. Crop models using outputs derived from climate models project potential yield changes, but they do not take into account terrestrial feed backs. Therefore, integration of crop models with land surface schemes such as C sequestration in global climate models would be important for more comprehensive assessments.

Atmospheric carbon comes from burning fossil fuels, decomposition of soil organic matter and deforestation and the sinks are oceans, soil and plants.

Spice based cropping systems and future research needs

Spices are grown in unique agro-ecological conditions in India and elsewhere. It is important to understand the differences in the ecological conditions and the factors that distinguish spice crop ecosystems from other agro-ecosystems. Basically, short and long rotation tree components in spice cultivation such as that of pepper, cardamom *etc.*, reduce emissions of atmospheric CO_2 in two ways: in C storage by afforestation and sustainable biofuels as substitute to fossil fuels. Moreover, nearly half of the C captured by the tree component is transported belowground through root growth and turnover processes of organic matter, thus increasing soil organic pool (Nair *et al.* 2010). Greater agrobiodiversity of home gardens, many of which include spices component, ensure longer stability of C storage in fluctuating environments. The forest like structure under such conditions, offer favourable nutrient cycling and increase soil organic carbon (Kumar 2011). Especially, such systems under small scale cultivation have higher C stocks than large and medium sized holdings; to the extent of 16-30 Mg C ha^{-1}. Globally it is recognized that CO_2 emissions will vary between industrial agriculture and small scale agro-ecological farms. Spices based agro-ecosystems contribute significantly less to global warming. Comparative CO_2 emissions from such systems (Table 2) show the prospects of spice growing regions in mitigating climate change. Studies on CO_2 emissions from spice eco-systems are required in India. Some recent studies have shown that in systems such as coffee + pepper + cardamom, soil organic C levels were high with the non-particulate carbon levels of 67.3 Mg ha^{-1} (ICAR-IISR 2015). Thus, improved mixed and intercropping systems involving spice crops have potential to reduce emissions of CO_2 and mitigate climate change. Also it is important to assess the C foot print in processing, storage and transport of spices.

Table 2. Comparative GHG emissions from various types of agricultural and forested systems

Land-use system	CO_2 emissions (mg C/m2/h)
Cropping system	
High-input cropping	84
Low-input cropping	66.6
Agroforestry systems	
Shifting cultivation	67.5
Multistate agroforestry	32.6
Peach palm	66.4
Forest	73.3

Source: (Brenda *et al.* 2011)

The future agenda for research include but not limited to the following areas:

- C balance sheet in spice eco-systems
- Long term CO_2 emission measurements
- Studies on soil organic carbon dynamics in spice eco-systems
- Carbon foot print in spices value-chains
- Integration of spice crop models with climate and C models
- Agronomic management methods for reduction of CO_2 emissions
- Cross-sector analysis of climate change factors for trade negotiations
- C reducing spices processing technologies

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Oral Presentations

O2

Importance of micronutrients and designer formulations for spices

V Srinivasan*, R Dinesh& S Hamza

ICAR-Indian Institute of Spices Research, Kozhikode-673012,Kerala
*vsrinivasan@spices.res.in

In India, spices were grown in around 3.16 million ha with an annual production of about 5908.3 thousand tonnes during 2013-14. The yield and quality of spices depend on the soils on which they are grown and their continuous exploitation without replenishing the nutrients especially micronutrients results in low yield, poor quality besides making the crop susceptible to pests and diseases. Excess use of high analysis NPK fertilizers rendered the soil deficient in micronutrients, which is one of the major reasons for non-flourishing of most of the crops. Besides, low pH and lower levels of organic carbon, K, Ca, Mg and Zn are the major constraints in spice growing soils. All India Coordinated Research Project on Micronutrients indicated deficiency of Zn, S, B, Mo, Fe, Mn and Cu, to the extent of 48, 41, 33, 13, 12, 5 and 4%, respectively. Recent studies in Kerala across 14 districts in different cropping systems showed that, soils were highly acidic (below 5.5 pH). More than 60% of the soils had very high (36-100 kg ha^{-1}) available P and exchangeable K level was low-medium (70%). Exchangeable Mg and B were low in 75% and 59% of the samples, respectively. As per ICRISAT survey, major spice growing tracts of Karnataka are acidic, high in organic carbon content, low to medium in K and just above critical limits in soil available Zn and B. In the major turmeric tract, Erode, Tamil Nadu, the nutrient imbalance is in the order of S > Ca > Na > Mg > Cu > Zn > K > B > Mn > P > N > Fe. Hence, there is an urgent need to develop crop specific micronutrient formulations in order to realize enhanced yield and quality. ICAR-IISR has developed designer formulations of micronutrients for major spices like ginger, turmeric, black pepper and cardamom. These micronutrient mixtures were designed to fulfill the requirement of the crop by maintaining optimal leaf nutrient ratio of secondary (Mg) and micronutrients (Zn and B) in the leaf. These crop specific mixtures are recommended as foliar spray during critical growth stages and they guarantee 10 to 25% increase in yield. For black pepper, 2-3 foliar sprays @5g/L should be done starting with spike initiation with the onset of monsoon and then at monthly intervals. For ginger and turmeric, as the soil nutrient availability varies with the type of soil, separate formulations based on soil pH have been designed. Cardamom mixture is also recommended as 2-3 foliar sprays @5 g/L during flowering and capsule development stages for a minimum yield increase of 10%. The composition is compatible with the normal fertilizers and can be mixed with common straight or complex fertilizers for application. An innate advantage of these mixtures is that they can also be used in organic agriculture at restricted amounts and are benign and environment friendly. The evaluation trials conducted at farmer's field in Kerala and Karnataka have shown a clear yield advantage of 10-30% in treated fields as compared to control. All these formulations have been licensed to private agencies for commercial production and supply.

O3

Climate change in the cloud forest cardamom hot spots in relation to cardamom productivity in Guatemala and India

Muthusamy Murugan*, Auvudai Anandhi[1], Raju Ravi[2], M K Dhanya & K B Deepthy

Cardamom Research Station, KAU, Pampadumpara-685553, Kerala
[1]College of Biological & Agricultural Systems Engineering, Florida A & M University, Tallahassee, Florida-32307, USA
[2]Department of Materials Engineering, Indian Institute of Science, Bengaluru-500012, Karnataka
*muthupeyan@gmail.com

Studies on climate-crop interrelationships are inevitable at this juncture. Guatemala and India are the toppers in the world jointly producing more than 90% of the world's small cardamom production. In Guatemala, it is produced in the high lands of Alta Verapaz while its production is mostly concentrated on the sloping lands of the Indian cardamom hills in India. Much of the world's cardamom production comes from erstwhile cloud forests or fragmented and degraded tropical cloud forests. The cardamom diversity in India was greater among the plantations until 1990's, of late, the introduction and higher adoption of farmers' varieties has completely wiped out its diversity from the plantations. All of the past cultivated types of cardamom (*Malabar* and *Mysore*) used to be shade loving, but current leading varieties are considered to be less shade adapted types. The differential adoption and response of cardamom types to present climatic change and variability need to be understood in order to develop varieties with desirable traits. The tropical cloud forests in mountains are highly vulnerable to climatic change and variability. Therefore, understanding the variability and change in the major and minor climatic elements from the measured and historical data will be useful for scientists and researchers as well as policy planners to manage and protect one of the most productive cardamom agro-forestry systems in the world. It is in this light, this presentation will center on unraveling the rate or levels at which the two cardamom hot spots are experiencing variable climatic change using appropriate statistical methods (Mann-Kendall 1945 and 1975; Sen Slope analysis).

This abstract focuses on climate data analysis particularly the atmospheric temperature, rainfall and relative humidity sourced from the representative climate station, Coban (Guatemala) and Pampadumpara (India). The data on these climatic variables were statistically analyzed and correlated with the cardamom growth, development and productivity. The data were collected from the relevant authorities of the respective hot spots. The results of the data analysis showed differential climatic variability between the two hot spots studied. Both the hot spots have experienced significant climatic variability, at least in one or two parameters. But higher variability and changes have been shown with Indian cardamom hot spot than that of Guatemalan hot spot. For instance, the diurnal temperature range was very high for Indian site than the Guatemalan spot. Greater variability in rainfall amounts and pattern has been observed for Indian cardamom hills than those of Alta Verapaz in Guatemala. Significant increases in major climatic elements were observed for both the spots depending on the time scales (temporal). Insect pest and disease incidence levels were higher for the Indian hot spot compared to the Guatemalan region during the study period. Increased and higher productivity levels of cardamom were reported for the Guatemalan sector during the recent and entire period analyzed. Indian cardamom hot spot also registered positive productive trend. Productivity levels were strongly correlatable with major climatic elements like precipitation amounts and pattern.

O4

Status of pesticide residues in major spice commodities

K Bhuvaneswari*, M Paramasivam & P Karthik

Department of Agricultural Entomology,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*bhuvanetnau@gmail.com

Pesticides are group of chemicals used against pests to protect crop and thereby to avoid economic yield loss. However, the level of pesticide residues in the harvested produce and their safety is of great concern among public. The regulations are available for use of pesticides and the permitted level of resulting residues in/on food commodities. Hence, monitoring and quantification is a critical stage in the management of agrochemicals and to ensure consumer safety. Modified QuEChERS (Quick Easy, Cheap, Effective, Rugged and Safe), a multi residue method was standardized and adopted to detect and quantify organochlorine, organophosphorus and synthetic pyrethroid residues in spice samples. Market samples of cardamom, pepper, red chilli, red chilli powder and curly leaf were collected from various parts of Tamil Nadu and monitored for pesticide residues. Totally 239 cardamom samples were collected and analysed for the presence of pesticide residues. In 33 cardamom samples, the level of quinalphos residues exceeded Maximum Residue Level (MRL) fixed by Food Safety and Standards Authority of India (FSSAI). Quinalphos, cypermethrin, lamda cyhalothrin, triazophos, chlorpyriphos, beta-cyfluthrin, ethion and bifenthrin residues were commonly detected. Out of total 223 pepper samples analysed, in two samples cypermethrin residues were detected. In dry chilli, 29 out of 67 samples analysed showed presence of ethion, triazophos, cypermethrin and profenophos residues. Residues of ethion, cypermethrin, bifenthrin, lamda cyhalothrin and profenophos were detected in 52 red chilli powder samples out of 114 market samples collected. Totally 512 curry leaf samples were collected and analysed and out of this 243 samples showed detectable level of profenophos, triazophos, quinalphos, cypermethrin, ethion, chlorpyriphos, bifenthrin, lamdacyhalothrin, dimethoate and fenvalerate residues.

In addition to monitoring studies, supervised trials were conducted to study the degradation pattern of pesticides commonly used by the farmers like diafenthiuron, monocrotophos, quinalphos, phorate, carbofuran and flubendiamide on cardamom; quinalphos, dimethoate, acephate, emamectin benzoate, spiromesifen and bifenthrin on chillies and dichlorvos, triazophos and dimethoate on curry leaf. Half life and waiting periods worked out are discussed.

O5

The black pepper-*Colletotrichum* host-pathosystem: Biology, epidemiology and management

C N Biju* & R Praveena

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*bijucn123@rediffmail.com

Anthracnose/fungal pollu incited by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc., the hemibiotrophic ascomycetous fungus is a major cause of concern in the black pepper growing regions. Studies were carried out at ICAR-IISR, Kozhikode during 2009-2014 to understand population biology of the pathogen, epidemiological and management aspects of the disease. Surveys undertaken in the major black pepper growing states of South India *viz*., Karnataka, Kerala and Tamil Nadu revealed the existence of considerable variability in the field populations of *C. gloeosporioides*, representing diverse agro-ecosystems. Investigations on epidemiology revealed that, maximum and minimum temperatures have negative correlation with disease incidence while, rainfall and number of rainy days have positive correlation with disease initiation and subsequent spread. The disease was initiated during the month of May-June, which subsequently progressed and attained maximum during the month of August. Surveys carried out in black pepper plantations and nurseries also shed light into over-summering of the pathogen in its perfect stage (perithecia), which may have implications on genetic recombination among the variant genotypes. It is also found that, the pathogen produce microsclerotia in the necrotic lesion on runner shoots (planting material) which could facilitate early initiation and spread of anthracnose in nurseries. Further, fungicide-based technology (treating cuttings intended for raising nursery with carbendazim-mancozeb 0.1%) was developed to manage the disease in nurseries. Plant extracts *viz*., *Solanum nigrum*, *S. torvum* and *Azadirachta indica* were also found effective in inhibiting the growth of *C. gloeosporioides* under *in vitro* conditions. Adopting prophylactic plant protection measures during the disease initiation phase *i.e*., foliar sprays with carbendazim-mancozeb (0.1%), at 30 days intervals (three sprays) proved to be effective in reducing the disease incidence under field conditions.

HS Mehta Memorial Award Presentations

H3

Identification of *Leaf curl virus* resistant genotypes in chilli through whitefly transmission and PCR

M Manikandan*, T Arumugam, T Saraswathy, S Harish & V A Sathiyamurthy

Department of Vegetable Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*mani.mytime@gmail.com

Chilli (*Capsicum annuum* L.), is the world's second most important solanaceous vegetable cum spices. Among the various production constraints, *Chilli leaf curl virus* belonging to *Begomovirus* genus is considered as an economically important disease which causes losses upto 80-85%. Possible approach to overcome this problem would be to identify genotypes with durable resistance to *Chilli leaf curl virus* and incorporate in the breeding programmes. In this study, an efficient protocol was optimized to screen chilli genotypes collected from various national and international institutions. Seventy five genotypes were screened under field condition during February-March 2015. The genotypes were narrowed down to thirty three based on reaction to the disease and subjected to artificial inoculation through whitefly transmission. Upon artificial inoculation, three genotypes *viz*., AVRDC 1127, AVPP 0716 and AVPP 0717 from AVRDC Taiwan, Bhut Jolokia from Nagaland and *C. frutescens* from Silent Valley, Kerala were found to be highly resistant, displaying no disease symptoms upto 60 days. To further confirm at molecular level, all the genotypes were screened using PCR with the coat protein gene specific primer of *Chilli leaf curl virus*. The results revealed that, most of the genotypes amplified the gene with a product size of 1 kb whereas, the resistant genotypes displayed a negative reaction. Thus, these genotypes with potential resistance to *Chilli leaf curl virus* can be exploited in the breeding programme to develop hybrids with resistance along with high yield and quality.

H4

Residues and dissipation of chlorfenapyr in chilli under field condition

P Karthik*, S Kuttalam, K Gunasekaran[1] & K Bhuvaneshwari

Department of Agricultural Entomology,
[1]Department of Nano Science & Technology,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*karthikento@gmail.com

The dissipation and residual level of chlorfenapyr in green chilli under field condition were determined using GC-ECD with QuEChERS method. At fortification level of 0.05, 0.1 and 0.5 ppm, the recoveries ranged from 85.7 to 89.49. The limit of quantification (LOQ) of the method was 0.05 mg kg^{-1}. The initial deposit of chlorfenapyr 10 SC @ 100 and 200 g a.i ha^{-1} was 0.1958 and 0.3267 µg g^{-1}, respectively. The dissipation rates of chlorfenapyr were described using first-order kinetics and its half-life worked out was 1.4 and 1.5 days for the recommended dose and the double the recommended dose, respectively. The terminal residues of chlorfenapyr reached below the detectable limit on 7^{th} day after application. The waiting period suggested after spraying chlorfenapyr 10 SC @100 and 200 g a.i

ha^{-1} was seven days (MRL 0.05 mg kg^{-1}). This study would help in providing the basic information for safe and regulated use of chlorfenapyr in chilli.

H5

Cassia occidentalis and *Curcuma longa* extract mediated synthesis of silver nanoparticles and their nematicidal activity against the root knot nematode *Meloidogyne incognita*

D Kalaiselvi* & P Sundararaj

Unit of Nematology, Department of Zoology,
Bharathiar University, Coimbatore-641046, Tamil Nadu
*dkalaiselvi19@gmail.com

One of the most wide-spread plant parasitic nematode infesting tomato is root-knot nematode (*Meloidogyne* spp.) which causes significant economic damage to the yield. It is of great interest for tomato producers to develop novel nematode control methods with effective, less toxic and environment-friendly active ingredients. In the present study, the efficacy of silver nanoparticles (AgNPs) at different concentrations was assessed on mortality and infectivity of *Meloidogyne incognita*. Silver nanoparticles produced by treating an aqueous solution of $AgNO_3$ (1 mM) with the leaf extract of *Cassia occidentalis* as a reducing agent of Ag^+ to Ag^0. *C. occidentalis* is an ayurvedic medicinal plant and its extracts are known to have antibacterial, antifungal, antimalarial, anti-inflammatory, antioxidant, hepatoprotective and also with immune-suppression activity. The synthesized nanoscale particles were analyzed by UV-vis spectrum, FT-IR, XRD, FESEM and EDX. When J_2 of *M. incognita* was exposed to AgNP in water with increasing concentrations from 0.1 to 10 µl/ml, 30% to 90% mortality was obtained in a dose-responsive manner. Infectivity studies confirmed that, infectivity of *M. incognita* J_2 were totally arrested by AgNPs. Results of the current studies showed that, the extract of *C. occidentalis* served as a good reducing agent for $AgNO_3$ and possess high potentials for the control of root-knot nematodes and could be the possible replacement for synthetic chemical nematicides.

H6

Factors affecting secondary metabolite production in *Nigella sativa* L.: Role of sowing window, nitrogen and phosphorus

K Giridhar*, G Sathyanarayana Reddy[1], S Surya Kumari, A Lalitha Kumari[2] & A Sivasankar[3]

Dr. YSR Horticultural University, AICRP on Spices, Guntur-522034, Andhra Pradesh
[1]SKL Telangana State Horticultural University, Rajendranagar-500030, Telangana
[2]Regional Research Unit (Soil Science & Agricultural Chemistry),
Regional Agricultural Research Station, ANGRAU, Guntur-522034, Andhra Pradesh
[3]Acharya NG Ranga Agricultural University, Rajendranagar-500030, Hyderabad, Telangana
*gkalidasu@yahoo.com

Nigella (*Nigella sativa*L.) is regarded highly in unani, ayurveda, siddha and other ethnomedicine systems. The changes in seed metabolite content was determined at varied sowing window (staggered by 15 days from 1st fortnight of October to 1st fortnight of December), graded levels of nitrogen (0 to 60 kg ha^{-1}) and phosphorus (0 to 45 kg ha^{-1}). The experiment was conducted at Horticultural Research Station, Guntur with cv. Ajmer Nigella-1. The GCMS profile of the seed metabolites showed the presence of ~150 compounds. Fatty acids and related compounds (~7 compounds) constituted the major portion. The volatile fraction had the presence of 19 major compounds. In the remaining metabolites, ~70 compounds were present in very low (≤ 0.04%) quantities and ~50 compounds were in traces. Irrespective of the date of sowing, graded levels of N and P application, linoleic acid content was higher followed by palmitic acid, methyl oleate, stearic acid, docosadienoic acid, myristic acid and lauric acid. The highest linoleic acid was observed with application of 0 kg N and 15 kg P ha^{-1} whereas; it was lowest without any nitrogen or phosphorus application. The highest thymoquinone content (1.3%) was observed with the crop sown during the 1st fortnight of October. There was no linear dependence for some of the volatiles on the N application. However, a few were positively (thymohydroquinone, γ-terpinene, β-pinene, sabinene and carvacrol) or negatively (thymoquinone, trans-4-methoxythujane and 9-undecenal, 2, 10- dimethyl) correlated. Production of most of the volatile metabolites was negatively correlated with P application. The highest thymoquinone (among total seed metabolites) content of 3.5% was observed in the treatment with 20 kg N and without any P application whereas, the lowest was observed with the application of 60 kg ha^{-1} nitrogen and 30 kg ha^{-1} phosphorus (1.2%).

H7

Special method of cultivation for root medicinal and aromatic crops

L Nalina* & K Rajamani

Department of Medicinal & Aromatic Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*lnalina_hort@rediffmail.com

Cultivation of root crops of medicinal and aromatic plants in vertical structure will be useful rather than field cultivation. In this special type of cultivation, more economic produce can be harvested. A trial was undertaken at HC & RI, Coimbatore on medicinal and aromatic crops *viz*., Ashwagandha, Satavari, Vetiver and Nannari. The results indicated that, vetiver recorded a root length of 119.50 cm and fresh weight of 430 g and dry weight of 175.6 g, respectively. Nannari produced 8 roots with a root length of 111.2 cm and fresh root weight of 50 g and dry root weight of 32.1 g. Ashwagandha produced 5 roots with a length of 76.8 cm and fresh weight of 290 g and dry weight of 95.6 g. Satavari recorded the maximum fresh weight of 785 g with 150 roots.

Poster Presentations

P46

Study on decadal changes of area and productivity of important crops of Kerala – GIS appraisal

K Jayarajan, Utpala Parthasarathy*, V Srinivasan, S Hamza & R Dinesh

ICAR-Indian Institute of Spices Research, Marikunnu, Kozhikode-673012, Kerala
*utpala@spices.res.in

The net area sown in Kerala rose from 28.85 Iakh ha in 1980-81 to 30.21 lakh ha in 1990-91, an increase of about 4.7 per cent. Significantly there is a decrease of 5.8 per cent during the decade 2000-2001 to 2011-2012. In 2001 total net sown area was 21.9 lakh ha to 20.71 lakh ha in 2012. The decadal growth rate of productivity of certain crops like paddy, coconut rubber, tapioca, cashew and black pepper were studied from 1970 to 2012, which indicated that, some districts like Thrissur and Kozhikode have a serious decline in the growth rate of the above crops while majority of the other districts showed decrease in cashew and black pepper. The classification of soil was considered critical to study to find out the reason of the decrease of the area under cultivation in Kerala as a whole and the reason of the decreased productivity of certain crops which used to consider highly suitable to the environmental condition of the coastal state Kerala. The study of soil quality of Kerala coordinated by the Kerala State Planning Board revealed the elevated levels of acidity in the soil samples of the agricultural fields across the State.The data mining recorded about the nutrient availability percentages of the soils in this record was the main resource in this study. With the help of GIS study and the statistics of the main crops area and productivity analysis was done which indicated that wide spread soil fertility related problems across districts are of concern for the productivity of different crops The main cause of decadal decrease of productivity of certain crops are related to the managerial or economic consequence.

P47

Integrated farming increases yield in black pepper

M Palanikumar*, J Prem Joshua, J D Nirmalatha & R Kannan

Horticultural Research Station, TNAU, Pechiparai-629161, Tamil Nadu
*mpkscientist@yahoo.co.in

An experiment was laid out at Horticultural Research Station, Pechiparai during 2009-12 with three treatments *viz.,* fully organic (T_1) (100 g *Azospirillum* + 10 kg FYM/vine), integrated (T_2) (100 g *Azospirillum* + 10 kg FYM + 100 g N + 40 g P_2O_5 + 140 g K_2O kg/vine) and fully inorganic (T_3) (100 g N + 40 g P_2O_5 and 140 g K_2O kg/vine) to study the influence of organic, inorganic and integrated farming on black pepper yield. Among the treatments, T_2 (integrated farming) recorded maximum dry berry yield during 2009-10, 2010-11 and 2011-12 (3.54 kg/vine, 3.52 kg/vine and 3.75 kg/vine, respectively) indicating the superiority of the integrated farming.

P48

Studies on the performance of black pepper in different alternate standards compared with *Erythrina*

R Swarnapriya* & R Kannan

Horticultural Research Station, TNAU, Pechiparai-629161, Tamil Nadu
*piriaragavan@yahoo.co.in

The gall wasp of *Erythrina* has devastated the pepper plantations and there is an essential need for a substitute standard for trailing pepper vines. Hence, an investigation was undertaken with seven live and three dead standards along with *Erythrina* as the control. The performance of Panniyur 1 black pepper was assessed on different standards. Among the different treatments, the highest vine length was recorded in the vines trained on *Glyricidia maculata*, followed by pepper grown on trellis with stone pillars. The least vine length was noticed on the standard *Ailanthus excelsa.* The highest number of plagiotropic shoots and spikes were observed in the standard *Simarouba glauca.* The highest dry berry yield of 1.23 kg/vine was also recorded in the same treatment, followed by *G. maculata* which was on par and recorded 1.051 kg/vine**.** Thedry berry yield of pepper vines trained on *Erythrina* was 0.91 kg/vine. Observation on per cent gall wasp incidence indicated that, 15.38 per cent *Erythrina* trees were affected while, such severe pest incidence was not recorded on other standards. Thus the study confirmed that, *Simarouba glauca* can be suggested as an alternate standard to *Erythrina* for growing pepper.

P49

Introduction of pepper as remunerative intercrop in coconut gardens of Thiruvarur district

V Sivakumar*, K Kumanan[1], A Kamaraj, R Ramesh & R Baskaran

ICAR-Krishi Vigyan Kendra, Needamangalam-614404, Tamil Nadu
[1]Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*shivafruitscience@gmail.com

The erstwhile Thanjavur district which has been trifurcated into Thanjavur, Thiruvarur and Nagapattinam districts is a fertile zone of Cauvery delta. Though this is the rice bowl of Tamil Nadu, coconut is also cultivated in more than 5000 hectares. But in almost all the plantations, coconut is cultivated solely without any intercropping except in very few pockets wherein, crops like banana and arecanut are cultivated as intercrops. The commercial cultivation of coconut intercropped with pepper using the available technologies for both the crops would result in boosting the farm income of coconut plantation in delta region. As there is great scope for the promotion of pepper as intercrop in coconut plantations in Cauvery delta, the farmers have to be trained on latest production technologies. On the above basis a front line demonstration on "Popularization of pepper as intercrop in coconut plantation" was conducted in ten locations of Thiruvarur district from 2013-015. For this demonstration, rooted cuttings of Panniyur-1 variety from Horticultural Research Station, Thadiyankudisai was introduced as intercrop in coconut plantations. The pepper vines were trained

on *Commiphora caudata*stands. The results revealed that, pepper as intercrop in coconut garden recorded a successful vine length (6 m), spike length (11.2 cm), number of berries per spike (56), dry yield per vine (1.21 kg) and dry recovery percentage (31%).

P50

Effect of growth promoting substances and sources of planting material on growth of bush black pepper

C K Thankamani*, K Prathyusha, S Hamza & K Kandiannan

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*thankamani@spices.res.in

Bush pepper, is a good option for urban horticulture with year round production of fresh green pepper. Normally cuttings collected from fruit bearing branches of one year old pepper vine is used for making bush pepper. Comparison of growth performance of bush pepper established from vine and bush pepper in pots is lacking. Hence, this experiment was conducted with 16 treatment combinations in factorial CRD with three replications at ICAR-Indian Institute of Spices Research, Kozhikode. Two varieties, Panniyur 1and Sreekara were used for planting with two sources of planting materials (vine pepper and bush pepper in pots) and three types of growth substances *viz*. indole butyric acid (1000 ppm), tender coconut water, Jeevamrutham and control. Regarding source of laterals, bush pepper produced using cuttings from vines had maximum root length (4.2 cm) which was significantly higher than bush pepper produced from bush pepper. Maximum length of roots was observed in the variety Panniyur 1 (12 cm) compared to Sreekara (6 cm). Regarding growth substances, the cuttings treated with Jeevamrutham had maximum root length (14.3 cm) and leaf production which was on par with treatments involving dipping of laterals in tender coconut water and IBA. Growth of bush pepper from laterals collected from vines grown on support trees were superior compared to that of bush pepper raised from pots. The results suggests the use of naturally available Jeevamrutham and tender coconut water as a substitute for IBA for inducing profuse rooting and better establishment.

P51

Standardization of fertigation schedule in small cardamom (*Elettaria cardamomum* Maton)

Manoj Oommen*, John Jo Varhgese & P Natarajan

Indian Cardamom Research Institute,
Spices Board,Myladumpara, Idukki-685553, Kerala
*manoj.oommen2014@gmail.com

Cardamom plantations are managed intensively by most of the farmers in cardamom hill reserve of Idukki district in Kerala. Fertigation will help cardamom farmers to improve fertilizer use efficiency and thereby increasing production and will also ensure sustainability of cardamom cultivation in the long run. A research work was carried out at Indian Cardamom Research Institute, Myladumpara,

Idukki during 2011-12 to 2013-14 to standardize fertigation schedule in cardamom. The experiment consisted of four treatments and seven replications in CRD. The treatments included application of NPK 150:150:300 kg ha^{-1} in 52 equal splits, application of NPK 150:150:300 kg ha^{-1} in 104 equal splits, application of NPK 150:150:300 kg ha^{-1} according to the physiological stages of the crop supplemented with mist irrigation and control (standard practice of soil application of NPK 150:150:300 kg ha^{-1} in three equal splits). The fertigation was carried utilizing the existing sub-surface in-line drip lines installed on both sides of the cardamom clump. Yield data were recorded periodically and analyzed statistically. Cardamom responded well to fertigation treatments during the experimental period. Pooled yield over three years indicated that, the application of fertilizers through irrigation has been superior when compared to the standard practice of soil application. Planning a fertigation schedule of recommended doses of fertilizers in equal splits at weekly intervals in a year was found to be effective in improving productivity. This schedule can be used as a basis for implementing precision farming of cardamom cultivation in future.

P52

Comparison of different management systems on soil nutrient availability, yield, quality and economics of ginger cultivation

V Srinivasan, C K Thankamani*, R Dinesh, S Hamza, T John Zachariah& K Kandiannan

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*thankamani@spices.res.in

A field experiment was conducted at ICAR- Indian Institute of Spices Research, Kozhikode during 2007-2012 to compare the effect of organic, chemical and integrated management systems on soil nutrient availability, yield and quality of ginger. The varieties *viz.,* Varada, Rejatha and Mahima were used with three treatments *viz*., 100% organic (30 t FYM + 2 t neem cake + 1 t ash + 4 t vermicompost per ha, biofertilizer - *Azospirillum* and *Pseudomonas*sp. as seed treatment and spray with Bordeaux mixture and neem oil for disease and pest control, respectively) (MP1), 100% inorganic (recommended dose of fertilizer NPK @75,50,50 kg/ha with recommended chemical methods of pest and disease control as per POP) (MP2) and integratedmanagement (20 t FYM + half the recommended N, full P and K + P- solubilizing bacteria and spray with dithane M-45 and quinalphos) (MP3). The soil nutrient status at 120 days after planting indicated that, pH (5.6), calcium content (813 mg/kg),phosphorus content (14.8 mg/kg), acid phosphatase (50.2 mg /g/PNP) and dehydrogenase activities (2.56 mg/g/ TPF) were higher under organic management system. While, soil potassium (250 mg/kg), alkaline phosphatase (4.11 mg/g/PNP) and phosphodiesterase (14.3 mg/g/PNP) activities were higher under integrated management system. The mean yield of ginger was higher under integrated system (14.45 t/ha) compared to organic system. Among the varieties, Mahima recorded maximum yield (28.3 t/ha) under integrated system. However, there was no significant difference among the management systems with respect to oil and oleoresin contents. The B:C ratio of organic system was found to be lower compared to integrated and inorganic systems.

P53

Influence of coloured shade nets on physiological parameters, yield and quality in ginger and turmeric

K S Krishnamurthy*& K Kandiannan

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*kskrishnamoorthy@spices.res.in

An experiment was conducted at ICAR-Indian Institute of Spices Research, Kozhikode during 2014-15 growing season to study the influence of red, black, white and green shade nets on partitioning percentage, photosynthetic and transpiration rates, yield and quality in ginger and turmeric. The plots were fully covered with shade net on all sides two months after planting. Open condition served as control. Results revealed that red shade net enhanced partitioning to rhizomes, improved photosynthetic rate, yield and quality in ginger. In turmeric also, better photosynthetic rate and quality attributes were observed under red shade net but the yield was maximum under white shade net.

P54

Evaluation of different types of fertilizers with micronutrients through fertigation on the yield performance of turmeric

G Thiyagarajan*, K Nagarajan[1]& P K Selvaraj[2]

Soil & Water Management Research Institute, TNAU, Thanjavur-613501, Tamil Nadu
[1]Water Technology Centre, TNAU, Coimbatore-641003, Tamil Nadu
[2]Agricultural Research Station, Bhavanisagar-638451, Tamil Nadu
*thiyagu@tnau.ac.in

An experiment was conducted for four years to evaluate the normal fertilizers and water soluble fertilizers through fertigation with micronutrients on the yield of turmeric at Agricultural Research Station, Bhavanisagar. The experiment consisted of ten treatments with normal and water soluble fertilizers. The trial was laid out in randomized block design with three replications. The results showed that, the treatment with 50% recommended N and K (Urea:163 kg ha^{-1}; MOP:90 kg ha^{-1}) through normal fertilizers + 50% N and K (Urea:163 kg ha^{-1}; SOP:108 kg ha^{-1}) through special water soluble fertilizers along with 100% recommended micronutrients (zinc sulphate:15 kg ha^{-1}; ferrous sulphate:30 kg ha^{-1}) through soil application was found to be superior than other treatments. Highest water use efficiency of 30.74 kg ha^{-1} mm^{-1} and B:C ratio of 4.37 were obtained in the same treatment.

P55

Effect of drip fertigation of N & K on the yield and water use efficiency of turmeric

G Thiyagarajan*, V Sivakumar[1] &M Manikandan[2]

Soil & Water Management Research Institute, TNAU, Thanjavur-613501, Tamil Nadu
[1]Krish Vigyan Kendra, TNAU, Needamangalam-614404, Tamil Nadu
[2]Agricultural Research Station, Bhavanisagar-638451, Tamil Nadu
*thiyagu@tnau.ac.in

Field experiments were conducted for three years at Agricultural Research Station, Bhavanisagar to optimize irrigation schedule and nitrogen (N) and potassium (K) requirement through fertigation for turmeric. The experiments were laid out in randomized block design with three replications. The treatments comprised of surface irrigation at 5 cm, 0.90 IW/CPE ratio with band placement of fertilizers, drip irrigation once in two days at 80, 60 and 40% of pan evaporation (PE) with 100, 75 and 50% of recommended dose of N and K through fertigation. Turmeric variety BSR 1 was used for the study in a plot of size 7.8 x 3.0 m. All the drip irrigation treatments 80, 60 and 40% of PE and 100, 75 and 50% of N & K through fertigation recorded significantly higher yields over surface irrigation with 100% RDF. There was irrigation water saving of 22, 36 and 49% in drip irrigation at 80, 60, 40% PE, respectively, compared to surface irrigation at 0.90 IW/CPE ratio. Water use efficiency was 81-128% higher in drip fertigation treatments over surface irrigation. Drip irrigation at 60% PE once in 2 days and fertigation levels of 50% of recommended N & K produced 40.1 t ha^{-1} yield which was comparable with 80% PE with 50% recommended N & K through fertigation. Irrigation water saving of 49% was recorded in drip irrigation at 40% PE compared to surface irrigation treatment.

P56

Influence of graded levels of potassium on growth, yield and quality of turmeric cv. BSR 2 in western zone Tamil Nadu

V Sivakumar*, V Subramanian[1], G Thiyagarajan[2]& R Baskaran

ICAR-Krishi Vigyan Kendra, Needamangalam-614404, Tamil Nadu
[1]Agricultural College & Research Institute, Killikulam-628252, Tamil Nadu
[2]Soil & Water Management Research Institute, Thanjavur-613501, Tamil Nadu
*shivafruitscience@gmail.com

Turmeric (*Curcuma longa* L.) is an herbaceous perennial belonging to the family *Zingiberaceae* and is one of the important commercial spice crops of the tropics. India is the largest producer, consumer and exporter of turmeric in the global arena. In Tamil Nadu, turmeric is cultivated mainly in Erode, Salem, Coimbatore and Namakkal. Being a nutrient exhaustive and owing to its long duration and high productivity, it requires heavy input of fertilizers especially potassium for higher productivity and quality. With this background, an investigation was carried out to study the effect of graded levels of potassium on growth and yield of turmeric cultivar BSR 2 under potassium depleted soil (Inceptisols) from April 2010 to April 2013 at Agricultural Research Station, Bhavanisagar, Erode, Tamil Nadu. The experiment comprised of eight treatment combinations with various levels of potassium with VAM

@20 kg per hectare. The experiment was laid out in strip plot design with three replications. Among the different treatment combinations, treatment with recommended dose of nitrogen and phosphorus + potassium @ 125 kg/ha + VAM @ 20 kg/ha recorded higher values for plant height (140.58 cm), number of leaves per plant (15.6), number of tillers per plant (4.4), leaf K content (3.71 per cent), soil available K content (242.63 kg ha^{-1}), number of mother rhizomes per plant (3.4), number of primary rhizomes per plant (11.2), number of secondary rhizomes per plant (15.4), mother rhizome weight (0.085 kg $plant^{-1}$), primary rhizome weight (0.165 kg $plant^{-1}$), yield (33.64 t ha^{-1}) and benefit cost ratio (3.74).

P57

Effect of biofertilizers and organic manures on soil fertility, growth, yield and quality of turmeric

Devendra Singh*, R C Nainwal & S K Tewari

CSIR-National Botanical Research Institute,Lucknow-226001, Uttar Pradesh
*singhdrdevendra@gmail.com

Organic farming is a crop production method which encourages sustainable agriculture by enhancing the biological cycles in nature. It is targeted for producing healthy, nutritive and pollution free food, by maximizing the use of on-farm resources and minimizing the use of off-farm resources. In this direction, a field experiment was carried out during 2014 and 2015 with the concept of organic nutrient management for cultivation of turmeric. The experiment was laid out in randomized block design and replicated thrice with 11 treatments *i.e,*.100% RDF (NPK + zinc) (T_1), vermicompost 20 tonnes/ha (T_2), coir compost (@5 t/ha) (T_3), 75% coir compost + 25% vermicompost (T_4), 75% vermicompost + 25% coir compost (T_5), 50% coir compost + 50% vermicompost (T_6), 100% vermicompost + PSB (T_7), 100% coir compost + PSB (T_8), 75% coir compost + 25% vermicompost + PSB (T_9), 75% vermicompost + 25% coir compost + PSB (T_{10}), 50% coir compost + *Azospirillum* + PSB (T_{11}). Different treatments significantly affected the growth attributing characters in comparison to control. The maximum plant height, leaf length and leaf width per plant were recorded in the treatment T_7, which was significantly higher than all the other treatments. Yield attributing characters like fresh weight of rhizomes, weight of mother rhizomes, weight of primary rhizomes per plant and total yield of rhizomes per hectare were also significantly affected the treatments with maximum in T_7 as compared to other nutritional treatments. However, application of recommended dose of fertilizer (T_1) was found statistically on par with T_{10}.

P58

Effect of size of rhizomes and growth regulators on growth and yield of turmeric var. Suroma

Ravi Pujari*, Shankargouda Patil, S Ajithkumar, M D Shashidhar, G Sharathbabu & Tammanna Wagh

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*pujariravihort556@gmail.com

An experiment was conducted to find out the effect of different rhizome sizes and growth regulators on growth and yield of turmeric, with three treatments of rhizome sizes *viz*., S_1-finger rhizomes used commercially (25 g), S_2-finger rhizomes of 10 g and S_3-finger rhizomes of 5 g and four treatments of growth regulators *viz*., G_1 (cycocel 1000 ppm), G_2 (6-BA 5 ppm), G_3 (NAA 20 ppm) and G_4 (control) which were replicated three times. Among the different treatments evaluated for growth and yield of turmeric, the treatment S_1 recorded maximum (81.57 cm) plant height, pseudostem girth (7.19 mm) and other vegetative parameters, yield per clump (321.63 g), yield per plot (7.42 kg) and yield per hectare (18.65 t/ha) at 180 DAP. Among the growth regulators used, G_3 (NAA 20 ppm) recorded maximum (80.84 cm) plant height, number of leaves per tiller (26.32) and other vegetative parameters, yield per clump (295.41 g), yield per plot (8.08 kg) and yield per hectare (18.08 t/ha) at 180 DAP. Among the interaction treatment, the treatment S_1G_3 (25 g + NAA 20 ppm) recorded maximum vegetative growth and yield per clump (426.69 g), yield per plot (10.25 kg) and yield per hectare (24.04 t/ha) at 180 DAP.

P59

Effect of manures and biofertilizers on growth and yield of turmeric (*Curcuma longa* L.)

M Chanchan*, D K Ghosh, J K Hore& M Anitha

Department of Spices & Plantation Crops, Faculty of Horticulture,
Bidhan Chandra KrishiViswavidyalaya, Nadia-741252, West Bengal
*chanchan.meinam17@gmail.com

A field experiment was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, during 2012-2014 to study the effect of biofertilizers in combination with organic manures and graded levels of inorganic fertilizers on growth and yield attributes of turmeric with 13 treatments including recommended NPK laid in RBD with three replications. The biofertilizer, arbuscular mycorrhizal fungus (*Glomus fasiculatum*) was applied to the soil along with compost/vermicompost and *Azospirillum lipoferum*was applied through seed treatment @5g/kg seed.The maximum plant height at 120 DAP (140.47 cm) and number of leaves at 60 DAP (5.23) was observed with compost + NP 100% + *Azospirillum* + AMF. Plants raised with vermicompost + NP 100% + *Azospirillum* + AMF recorded the maximum number of tillers (2.25) at 120 DAP. Maximum clump weight (378.38 g) and yield per plot (13.94 kg) were recorded with vermicompost + NP 75% + *Azospirillum* + AMF.

P60

Standardization of planting season of turmeric raised by seedling transplantation technique

P Hemalatha*, R Chitra& M Mohamed Yassin

Agricultural Research Station, TNAU, Bhavanisagar-638451, Erode, Tamil Nadu
*hemahort@yahoo.com

An experiment was conducted at Agricultural Research Station, Bhavanisagar to standardize the planting season of turmeric raised by transplanting seedlings during June 2011 to May 2013. In this experiment, the rhizome derived plants during June month and the turmeric seedlings transplanted during 15th day of seven different months *i.e.*, June, July, August, September, October, November and December were evaluated. The experiment was carried out in randomized block design with three replications. The observations clearly indicated that, planting season has pronounced effect on growth and yield of turmeric. The prominent plant height (116.19 cm) and number of leaves (13.13) were recorded in June month planting while, higher number of tillers per plant (4.6) in July month planting. The incidence of shoot borer was comparatively low on the seedlings planted during June (0.84%), July (1.13%) and August (1.16%). Similar trend was also observed with respect to incidence of rhizome scale and rhizome rot. Further, planting of seedlings in June recorded the highest fresh rhizome weight per plant (1.176 kg), dry rhizome weight per plant (0.242 kg), fresh rhizome yield (47.18 t/ha) and dry rhizome yield (9.70 t/ha). The June month seedling planting also resulted in higher gross (Rs. 268800/ha) and net returns (Rs. 186750/ha) as well as B:C ratio (2.28:1).

P61

Effect of different planting methods and spacings on growth and yield performance of turmeric

V S Kale*, P K Nagre,A P Wagh & U A Raut

Department of Horticulture,
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444104, Maharashtra
*vijayskale72@gmail.com

An experiment was carried out to study the effect of different planting methods and spacings on growth performance and yield of turmeric at the Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2011-12. The experiment was conducted in randomized block design with eight treatments (two planting methods-BBF and ridges and furrows, in combination with four spacings *viz*., 30 x 22.5 cm, 30 x 30 cm, 45 x 22.5 cm and 45 x 30 cm) replicated thrice using cv. Waigoan. The results indicated that, significantly higher mother rhizome yield per plot (10.29 kg) and per ha (137.21 q/ha) were obtained with 30 x 22.5 cm spacing in BBF method. The similar trend was observed for fresh yield of turmeric fingers per plot (30.19 kg) and yield per ha (402 q/ha).

P62

Influence of manures and biofertilizers on cost of cultivation of turmeric (*Curcuma longa* L.)

M Chanchan, D K Ghosh, M Anitha* & J K Hore

Department of Spices & Plantation Crops, Faculty of Horticulture,
Bidhan Chandra Krishi Viswavidyalaya, Nadia-741252, West Bengal
*anithamajji01@gmail.com

An experiment was carried out to study the influence of manures and biofertilizers on cost of cultivation of turmeric at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya during 2012-2014 with thirteen treatments (along with inorganic NPK) laid out in RBD with three replications. The organic inputs namely, compost and vermicompost were applied basally. The biofertilizer, arbuscular mycorrhizal fungus (*Glomus fasiculatum*) was applied along with compost/vermicompost and *Azospirillum lipoferum* was applied through seed treatment. Inorganic fertilizers were apllied as per recommendation (150:60:150 kg NPK/ha). It is concluded that, considering the yield, net return and B:C ratio, the treatments *viz*., compost + NP (75%) + *Azospirillum* + AMF and vermicompost + NP (75%) + *Azospirillum* + AMF were superior and economically viable.

P63

Performance of different turmeric varieties under organic cultivation

C K Thankamani*, V Srinivasan, R Dinesh, S Hamza, O Shajina, P G Unmesh& T John Zachariah

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*thankamani@spices.res.in

Turmeric (*Curcuma longa* L.) a rhizomatous, zingiberaceous perennial herb is a major spice and medicinal crop used as spice and condiment, dye, cosmetics and as drugs, especially curcumin for the treatment of cancer. A field experiment was conducted at ICAR-Indian Institute of Spices Research, Kozhikode during 2013-14 and 2014-15 to study the performance of eleven turmeric varieties *viz.*, Prathibha, Alleppey Supreme, Varna, Sobha, Sona, Kanthi, Suvarna, Suguna, Sudarshana, Kedaram and Prabha under organic farming in RBD design with four replications. The plants were managed as per organic package developed by ICAR-IISR. Results showed that, under organic cultivation, Sudarshana recorded significantly higher yield (25.7 t/ha), followed by Suguna and Kedaram while, Varna recorded lowest yield (14.6 t/ha). The variety Suguna recorded significantly higher oil content (2.26%). The varieties *viz*., Alleppey Supreme, Suguna, Sudarshana, Kedaram and Prabha recorded higher oleoresin content and were on par. Alleppey Supreme recorded maximum curcumin content which was on par with Prathibha, Suguna, Kedaram and Prabha whereas, Sona recorded lowest curcumin content. The results indicated that, Suguna, Sudarshana and Kedaram with high yield as well as quality are more suitable varieties for organic management.

P64

Studies on effect of shade and integrated nutrient managementon biochemical composition of turmeric

S Padmapriya* & N Chezhiyan

Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*spadmapriyaa@yahoo.co.in

An experiment was conducted at HC & RI, Coimbatore to determine the effect of shade and integrated nutrient management on biochemical parameters of turmeric cv. CL 147. The experiment was laid out in split plot design with two replications. Partial shade was provided by sesban (*Sesbania sesban)* and castor (*Ricinus communis*) (main plot) and the sub-plots included different combinations of inorganic, organic and biofertilizers. Observation on biochemical attributes *viz*., chlorophyll, soluble protein, IAA oxidase and total phenol contents were recorded at different stages of plant growth. The results indicated that, M_2S_8 [shade + 100% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + panchagavya (3%)] resulted in increased total chlorophyll (1.889 mg g^{-1}) and total phenol (120.63 µg g^{-1}) contents. Whereas the treatment, M_1S_8 [open + 100% NPK + 50% FYM (15 t ha^{-1}) + coir compost (10 t ha^{-1}) + *Azospirillum* (10 kg ha^{-1}) + phosphobacteria (10 kg ha^{-1}) + panchagavya (3%)] exhibited highest soluble protein (85.89 mg g^{-1}) and IAA oxidase (943.70 µg of IAA oxidized g^{-1} hr^{-1}) activity as compared to reduced soluble protein (61.53 mg g^{-1}) and IAA oxidase (728.9 µg of IAA oxidized g^{-1} hr^{-1}) in M_2S_{20} (shade + absolute control) at 180 DAP.

P65

Studies on water requirement of turmeric (*Curcuma longa* L.) var. CO 2

Ramesh M Havaraddi, S Subramanian*, R Chitra & J Suresh

Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*hrstkd@tnau.ac.in

A field trial was carried out at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2013-2014 to standardize the water requirement for turmeric var. CO 2 to improve growth, yield, quality and also to assess the efficiency and economics of drip irrigation in comparison with surface irrigation. The experiments consisted of, T_1-drip irrigation every day at 80% PE, T_2 -drip irrigation once in two days at 80% PE, T_3 -drip irrigation every day at 60% PE, T_4-drip irrigation once in two days at 60% PE, T_5 -drip irrigation every day at 40% PE, T_6-drip irrigation once in two days at 40% PE and T_7-surface irrigation at 0.9 IW/CPE at 5 cm depth (control). The study revealed that, T_1 was superior for morphological characters *viz*., plant height (87.59 cm), number of leaves (9) and number of tillers (4.1) as well as physiological parameters *viz*., leaf area (3313.53 cm^2), leaf area index (4.91), leaf area duration (188.36 days), specific leaf weight (6.68 g cm^{-2}), dry matter production (101.68 g $plant^{-1}$), relative water content (91.65 %), chlorophyll stability index (89.02%), soluble protein (71 mg g^{-1}) and nitrate reductase activity (7.14 µg of NO_2/g/h). The yield parameters *viz*., number of mother rhizomes (3.3), primary rhizomes (12.5), secondary rhizomes (18.29) and weight of

mother rhizomes (88.85 g), primary rhizomes (168.89 g) and secondary rhizomes (89.18 g) per plant and estimated fresh rhizome yield (43.52 t ha^{-1}) were higher in T_1. The highest estimated cured rhizome yield was obtained in T_1 (7.79 t ha^{-1}) whereas, the lowest was in T_7 (5.35 t ha^{-1}). Higher values for quality parameters *viz.*, curcumin (4.26%), oleoresin (8.69%) and essential oil (3.67%) contents were also registered with T_1. Economic analysis revealed that, T_1 registered highest net returns (5.83 lakhs ha^{-1}) and BCR (4.98).

P66

Effect of planting dates and *Mycorrhizal fungi* association on growth and yield of turmeric (*Curcuma longa* L.) cv. Salem

Uttam Tripura*, N K Hegde & Chaya P Patil

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591310, Karnataka
*uttam_uhs@yahoo.in

An investigation was carried out to find out the suitable planting dates and mycorrhizal association on growth and yield of turmeric (*Curcuma longa* L.) cv. Salem during 2011-2012 at KRC College of Horticulture, Arabhavi, Karnataka. Experiment was laid out in split plot design with three replications. The experiment consisted of six fortnightly planting dates starting from 2nd fortnight of April to 1st fortnight of July as main treatments and two sub-plot treatments *viz.*, with or without application of VAM (*Glomus fasiculatum*). Various growth parameters *viz.,* plant height, number of tillers per clump, number of leaves per clump and leaf area were recorded at monthly intervals *i.e.,* 60, 90, 120, 150 and 180 days after planting (DAP). Highest plant height, number of tillers per clump, number of leaves per clump and leaf area were recorded by crop planted on 2nd fortnight of May (102.79 cm, 9.20, 88.97 and 63.56 dm^{-2}, respectively), followed by 1st fortnight of May (96.04 cm, 8.37, 83.7 and 60.16 dm^{-2}, respectively). Fresh rhizome yield per hectare was also significantly higher in the crop planted in 2nd fortnight of May (47.33 t ha^{-1}), followed by 1st fortnight of May (38.03 t ha^{-1}) and the lowest was noticed by the crop planted in 1st fortnight of July (4.7 t ha^{-1}). Similarly, the curing percentage and estimated cured yield were significantly higher in crop planted in 2nd fortnight of May (34% and 16.12 t ha^{-1}, respectively) compared to the lowest in crop planted in 1st fortnight of July (20.68% and 0.98 t/ha, respectively). Hence, planting of turmeric during 2nd fortnight of May with mycorrhizal association is ideal under northern dry zone of Karnataka.

P67

Studies on pruning of hanging shoots and withholding of irrigation at different time intervals on flowering and bean yield of vanilla (*Vanilla planifolia* Andrews)

A Subbiah*, R Jagadeesan, A Rameshkumar & N Chezhiyan

Grapes Research Station, TNAU, Anaimalayanpatty, Theni-625526, Tamil Nadu
*cardamomsubbiah@gmail.com

A field experiment was undertaken to study the effect of pruning hanging shoots and withholding irrigation at different time intervals on growth, development, flowering, yield and quality of vanilla

(*Vanilla planifolia*). The hanging shoots were pruned at various node intervals (6, 8, 10 and 12). In general, there was reduction in shoot and root dry weight when water stress advanced. The treatment combination of pruning at 10^{th} node and withholding irrigation for 30 days maintained better physiological status in terms of lower transpiration rate, loss in membrane integrity and stomatal diffusive resistance. However, the highest total chlorophyll content, chlorophyll stability index, relative water content, leaf water potential and photosynthesis yield were recorded in the treatment involving no pruning and withholding irrigation for 30 days. The treatment combination of pruning at 12^{th} node and withholding irrigation for 60 days showed higher values for stress enzymes such as catalase, peroxidase and superoxide dismutase besides maintaining higher soil water potential and available soil moisture. The treatment combination, pruning at 12^{th} node and withholding irrigation for 60 days recorded higher number of flower buds per vine, number of spikes per vine, number of florets per spike, number of beans per vine (70.25) and bean yield per vine (1163.24 g).

P68

Effect of different shade intensities of standard trees on growth, photosynthetic activity and bean yield of vanilla (*Vanilla planifolia* Andrews)

A Subbiah*, R Jagadeesan, A Rameshkumar & N Chezhiyan

Grapes Research Station, TNAU, Anaimalayanpatty, Theni-625526, Tamil Nadu
*cardamomsubbiah@gmail.com

A field experiment was carried out to study the effect of shade intensities on growth and photosynthesis of vanilla (*Vanilla planifolia*). The vines were allowed to trail on *Gliricidia maculata* grown under coconut-based cropping system. The results revealed that, pruning standard trees thrice during July, September and November months registered more number of leaves per vine (140). The highest leaf length (25.6 cm), leaf breadth (7.3 cm) and leaf area (131.25 cm^2) were noticed in the treatment, pruning standard trees thrice during June, August and October months. The light interception was maximum (135.08 $\mu\varepsilon m^{-1}s^{-1}$) in June, July, August, September and October. Light reflection co-efficient exhibited an increasing trend from March to June, which was subsequently reduced slightly and came down during November to February and the difference was statistically significant. The light reflection co-efficient ranged between 1.78 (December) and 3.94 (May). The highest photosynthetic yield (6.08 μ mol CO_2 m^{-2}) was observed with pruning during June, July, August, September and October. The same treatment also registered the highest green bean yield per vine (1155.19 g).

P69

Effect of plant growth regulators and certain organic substances on bean yield, quality and vanillin content in vanilla (*Vanilla planifolia* Andrews)

A Subbiah*, A Rameshkumar, R Jagadeesan & N Chezhiyan

Grapes Research Station, TNAU, Anaimalayanpatty, Theni-625526, Tamil Nadu
*cardamomsubbiah@gmail.com

An investigation was undertaken to study the effect of plant growth regulators and certain organics on bean yield and quality of vanilla (*Vanilla planifolia*) at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Among the treatments, post-flowering spray of NAA (25 ppm) recorded the highest bean set (95.88%). The highest pollen viability (93.69%) was registered with spray of panchagavya (2.5%), while there was a reduction with GA_3 (50 ppm). The highest number of beans per spike (18.55), number of spikes and green bean yield per vine were recorded with pre-blooming spray of amino acid mixture (0.01%) + post-flowering spray of NAA (25 ppm) (1635.25 g). The length and girth of the bean (25.4 cm and 3.86 cm) were the highest with BA (10 ppm) + GA_3 (25 ppm). The quality traits *viz.,* weight of seed mass, curing per cent, total phenol content were the highest in pre-blooming spray of amino acid mixture (0.01%) + post-flowering spray of NAA (25 ppm). The post-bloom spray of BA (10 ppm) + GA_3 (25ppm) recorded higher β-glucosidase activity (75.36 μg g^{-1} h^{-1}) and vanillin content (2.35%). Combined application of pre-blooming spray of amino acid mixture (0.01%) + post-flowering spray of NAA (25 ppm) was found to be economically viable with higher B:C ratio. Though the highest yield was realized with growth regulators, BA (10 ppm) + GA_3 (25ppm) and BA (20 ppm) + GA_3 (50 ppm), the treatments recorded relatively lower B:C ratio, due to their higher cost.

P70

Management of sucking insect pests in black pepper, *Piper nigrum*

P Thilagam* & K Nageswari

Regional Research Station, TNAU,Paiyur-635112, Tamil Nadu
*pthilagam@rediffmail.com

A set of field experiments was conducted at Horticultural Research Station, Yercaud for evaluating the efficacy of botanicals, bio-insecticide and newer chemical insecticides against the sucking insects in black pepper. Under main field condition, the black pepper vines were observedfor the sucking insects *viz.,* leaf gall thrips, *Liothrips karynii* and mealybug, *Ferrisia virgata*. Totally two sprays were taken against the above insects and the population were recorded in different treatments at different time intervals. Observations on the treated vines were taken on 1 and 3 days after treatment (DAT). The results revealed that, imidacloprid 17.8% SL@0.3ml/l recorded 0.7 thrips per leaf with 87 per cent reduction. The standard chemical insecticide *viz*., chlorpyriphos 20 EC @2 ml/l was on par with fipronil 5% SC @1.5 ml/l and azadirachtin 1% EC @3 ml/l. Bio-insecticide, *Beauveria bassiana* @10 g/l was found to be on par with chemical insecticide, triazophos 40 EC @2 ml/l which recorded 4.7 mealybugs per leaf with 6 per cent reduction after one DAT. It was also found that, the treatments, imidacloprid 17.8% SL @0.3 ml/l and fipronil 5% SC @1.5 ml/l were significantly superior and on par

over all other treatments imposed in controlling both leaf gall thrips and mealybug population. During the second application, all the treatments including the standard chemical insecticide were found to be on par with each other statistically, but there was a difference in the intensity of the population recorded which ranged from 1.3 to 3.0 mealy bugs per leaf.

P71

Compatibility of plant growth promoting rhizobacteria with plant protection chemicals

U Keerthana[1], A Lijina, R Praveena* & M Anandaraj

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
[1]ICAR-Central Plantation Crops Research Institute, Regional Station, Vittal-574243, Karnataka
*praveena@spices.res.in

In the integrated pest management schedules, application of chemical pesticides along with plant growth promoting rhizobacteria (PGPR) and biological control agents are increasingly common. Plant growth promoting rhizobacteria *viz*., *Micrococcus lutieus* (BRB 3), *Enterobacter aerogenes* (BRB 13), *Micrococcus* sp. (BRB 23), *Bacillus amyloliquefaciens* (GRB 35), *Microbacterium paraoxidans* (FL 18) and *Pseudomonas putida* (FK 14) are being used in black pepper, ginger and seed spices to enhance growth and also to manage diseases. An *in vitro* study using agar well diffusion technique was undertaken to test the compatibility of PGPR isolates with commonly used plant protection chemicals in black pepper, ginger and seed spices. The nine fungicides *viz*., propiconazole, krexosim- methyl, new fungicide molecule of Rallis India Ltd., carbendazim, copper oxychloride, mancozeb, metalaxyl-mancozeb, azoxystrobin, thiram and three insecticides *viz*., deltamethrin, dimethoate and imidacloprid were tested at 5 concentrations *i.e*., the recommended dose and two lower and two higher doses. The study revealed that, the black pepper isolates, *M. lutieus*, *E. aerogenes* and *Micrococcus* sp. were compatible with the soil drenching fungicide, metalaxyl-mancozeb whereas, *Micrococcus* sp. was incompatible with copper oxychloride at all concentrations tested. The ginger isolate GRB 35, a biocontrol agent used against ginger rhizome diseases showed incompatible reaction with metalaxyl-mancozeb, copper oxychloride and mancozeb. The PGPR isolates, FL 18 and FK 14 used for seed coating in seed spices, fennel and fenugreek, respectively were incompatible with commonly used seed treating fungicide, thiram. The PGPR isolates showed compatible reaction with the insecticides tested at all concentrations. The study indicated the incompatibility between PGPR and fungicides and to avoid the deleterious effects, incompatible plant protection chemicals need not be applied along with plant growth promoting rhizobacteria under field conditions.

P72

Cost effective diet for commercial multiplication of *Galleria mellonella*, the host worm for EPN to control cardamom root grubs

Reesamol G Vaz*, Sheen Scariah & Sijo Jose

Peermade Development Society, Peermade-685531, Idukki, Kerala
*reesamolgvaz@gmail.com

Cardamom root grub, *Basilepta fulvicorne* is a serious pest causing 10-70% yield loss under various levels of infestation. A native species of EPN, *Heterorhabditis indica* (strain ICRI 18) extracted from cardamom soil reared on *G. melonella*, was found to be highly pathogenic and virulent on cardamom root grubs. Under laboratory conditions, the larvae of *G. mellonella*, were mass multiplied by providing artificial diet which includes costlier items like honey, glycerine, milk powder etc. which increases the cost of production. Hence, studies on developing cheaper diet were carried out at Shyadri Research Institute, Peermade by experimental modification of diet developed by PDBC, Bangalore and modified by ICRI, Myladumpara. The first combination (T_1) contained dog feed, dried yeast and honey, second one (T_2) was prepared with different cereals, dried yeast, honey and glycerine, third (T_3) was made of dog feed, dried yeast and cane sugar in water, fourth (T_4) combination was modified by replacing milk powder with ragi powder, fifth one (T_5) composed of wheat bran, dried yeast ,honey and glycerine and the last (T_6) was with maize flour, ragi powder, dried yeast, honey and glycerine. Biological parameters like larval weight, larval length and larval period were assessed. Among six combinations studied, T_4 was superior in terms of biological parameters and economic feasibility. In T_4, cost was reduced by 47.15% compared to that of PDBC media and 34.56% to that of ICRI media. The identified composition can be successfully used for commercial rearing of the *Galleria* larvae for *in vivo* mass multiplication of EPN.

P73

Evaluation of new insecticides/biopesticides in cardamom against thrips and shoot and capsule borer

K B Deepthy*, R Narayana[1], M K Dhanya, T Maya & M Murugan

Cardamom Research Station, KAU, Pampadumpara-685553, Idukki, Kerala
[1]College of Agriculture, KAU, Vellayani, Thiruvananthapuram-695522, Kerala
*deepthyagri@yahoo.co.in

Cardamom is one of the costliest spice crops grown mainly in the Cardamom Hill Reserves (CHR) of the Southern Western Ghats. Thrips (*Sciothrips cardamomi*) and shoot and capsule borer (*Conogethes punctiferalis*) are the two major pests, limiting the production of cardamom. Intensive cultivation of cardamom in CHR has ended up with indiscriminate use of pesticides that led to the higher population pressure of sucking pests. The present investigation was undertaken to evaluate the efficacy of different chemicals and bio-pesticides against thrips and shoot borer. The experiment was conducted at CRS, Pampadumpara for three years. Pooled analysis for three years showed that, imidacloprid (6.11%) was most effective against thrips, followed by quinalphos (18.21%) and carbosulfan

(18.33%). In the case of shoot and capsule borer, during the first year, the lowest infestation was reported with quinalphos followed by carbosulfan, chlorpyriphos and poneem. During second year, the lowest shoot borer infestation was recorded with poneem followed by quinalphos and chlorpyriphos. Study conducted at third year revealed that, shoot borer infestation was minimum with poneem (3.16%) followed by acetamiprid (4.03%), quinalphos and carbosulfan. Imidacloprid registered the lowest thrips infestation followed by carbosulfan and acetamiprid. The infestation of both thrips and borer were considerably low with the application of carbosulfan and quinalphos and minimum incidence of borer was observed with poneem.

P74

Effect of changing climatic factors and management practices on pests, pollinators and natural enemies of small cardamom (*Elettaria cardamomum* Maton)

M A Ansar Ali*, T Manoharan, S Kuttalam, P Paramaguru[1]& S Nakkeeran[2]

Department of Agricultural Entomology, CPPS,
Agricultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[1]Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[2]Department of Plant Pathology, CPPS, TNAU, Coimbatore-641003, Tamil Nadu
*sbansarent.6@gmail.com

Indiscriminate application of harmful, tankmix and readymix formulations of several pesticides and changing management practices resulted in pesticide residues in cardamom capsules and also ecosystem destructions. The different management systems *viz*., high, medium and low input applied plantations were surveyed for the incidence of major and minor pests, pollinators (honey bees) and biocontrol agents (parasitoids, predators, EPF and EPN). Also a bio-rational pest management strategy with native, potential biocontrol agents against major pests was developed and validated under field condition. During the survey, natural parasitization of braconids (*Apanteles taragamae* and *Glyptapanteles*) was recorded upto 20-30% on *Conogethes punctiferlalis* for the first time in cardamom. The resurgence of thrips*, Sciothrips cardamomi* and outbreak of minor pests *viz.,* whitefly and red spider mites were noticed in the plots applied with lambda cyhalothrin 5 EC and several tankmix combinations of synthetic pyrethroids with OP and newer group of insecticides. The root grub, *Basilepta fulvicorne* was significantly controlled by application of cadaver formulation of native entomopathogenic nematode, *Heterorhabditis indica* (ICRI EPN-18strain) @150000 Ij_s per clump/plant. The cardamom whitefly (*Singiella cardamomi*) and red spider mite (*Tetranychus* sp.) were significantly controlled by the application of a biocide (Eco-1) @100 ml/100lof water. The native isolates of EPF-*Metarhizium* and *Beauveria bassiana* and EPN-*H. indica* successfully cross infected the larvae of *C. punctiferalis* under laboratory condition.

P75

Quantitative and qualitative changes in small cardamom, *Elettariacardamomum*Maton as induced by thrips, *Sciothrips cardamom* Ramk.infestation

A Josephrajkumar*, M Murugan, S Sivakumar[1], K B Deepthy[2], M K Dhanya[2],
T Maya & K P Kuriakose

ICAR-Central Plantation Crops Research Institute,Regional Station, Kayamkulam-690533, Kerala
[1]ICAR-National Bureau of Agricultural Insect Resources, Bengaluru-560024, Karnataka
[2]Cardamom Research Station, KAU, Pampadumpara-685553, Idukki, Kerala
*joecpcri@gmail.com

Small cardamom (*Elettariacardamomum*Maton) is grown in India, Gautemala, Sri Lanka and Tanzania. The quality of cardamom is assessed based on colour, appearance, shape as well as scented aroma of the cured capsules. Itch-free capsules are preferred to itched or scabbed capsules because of the perception that itched capsules have less aromatic principles and reduced drying percentage. Hence, the present study was undertaken to understand the quantitative and qualitative changes in small cardamom induced by thrips infestation. The results showed that, weight of 100 fresh and dry capsules decreased significantly as the severity of thrips damage increased. However, no significant differences were observed in the number of seeds per capsule as well as driage percentage of healthy and itched capsules. In the matured capsules (both the black seeds and dried black seeds), thrips infestation resulted in higher peptidase activity (37.09 & 16.20 nmole pNP/min/mg protein, respectively) when compared to those of healthy capsules (34.28 and 10.60 nmole pNP/min/mg protein, respectively). The activity of trypsin-like protease was higher in thrips infested capsules. The volatile oil content of both healthy and thrips infested capsules didn't differ significantly, but the 1,8-cineole content was higher in thrips infested capsules. The present investigation revealed that, even though there was significant variation in quantitative parameters of both healthy and thrips infested capsules, there was no variation in the qualitative parameters and the thrips infested capsules were not inferior in quality.

P76

Cardamom red spider mite (*Tetranychus urticae)* - occurrence and infestation in relation to high-range weather condition in Idukki district

M K Dhanya*, V S Manoj, K B Deepthy& M Murugan

Cardamom Research Station, KAU, Pampadumpara-685553, Idukki, Kerala
*dhanya_mk2000@yahoo.co.in

A survey was conducted during 2014 to assess the level of occurrence and infestation of cardamom spider mite in three panchayaths *viz*., Nedumkandam, Karunapuram and Chakkupallam of Idukki, Kerala. Observations on percent incidence on leaf were recorded at fortnightly intervals and correlated with climatic parameters recorded at Cardamom Research Station, Pampadumpara. Observations and analysis of the data showed an increasing trend in the occurrence and infestation levels of the pest during summer and rainy months. Highest infestation and occurrence were registered in May, June,

July and August months. It was found that, the pest occurrence was not reduced even during rainy months. Relative humidity showed a negative correlation with the incidence in Nedumkandam panchayath whereas; a positive correlation was observed in other two panchayaths. The positive and negative correlations reported in these places were not statistically significant. Maximum and minimum temperature as well as sunshine hours showed significant positive correlation with the incidence. Diurnal variation in temperature had negative correlation and was not statistically significant. Total rainfall showed positive trend but it was non-significant statistically in all the panchayaths. The result on temperature levels, especially rise in the minimum temperature was the most deciding climatic element on the incidence of red spider mite in cardamom. On the whole it is expected that, the current minor pest might become a major pest in the future changing climatic scenario particularly the asymmetric increase in atmospheric temperature minima.

P77

Oscheius spp. as an alternative to *Heterorhabditis* spp. for ecofriendly management of cardamom root grub (*Basilepta fulvicorne* Jacoby)

Rashid Pervez*, Santhosh J Eapen, S Devasahayam, T K Jacob, M Ansar Ali[1]& P Thyagarajan[1]

Division of Crop Protection,
ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
[1]Indian Cardamom Research Institute, Myladumpara-685553, Idukki, Kerala
*rashid_pervez@rediffmail.com

Root grub (*Basilepta fulvicorne* Jacoby) is an important soil-borne pest of cardamom. Pesticides are generally used to manage this pest, though there are recent reports of deploying entomopathogenic nematodes (EPNs). In the present study, efficacy of eight native EPNs, *Heterorhabditis* sp. (IISR-EPN 01), *Steinernema* sp.(IISR-EPN 02), *S.ramanai* (IISR-EPN 03), *S. carpocapsae* (IISR-EPN 06), *Oscheius* spp. (IISR-EPN 04, 05 and 08) and *O. gingeri*(IISR-EPN 07) were tested against cardamom root grub. Among them, *Heterorhabditis* sp. (IISR-EPN 01) and *O. gingeri*(IISR-EPN 07) were found more pathogenic to root grubs, as they caused 100 per cent mortality within 72 h, followed by *S.ramanai*(IISR-EPN 03), *S. carpocapsae*(IISR-EPN 06) and *Oscheius* sp. (IISR-EPN 08).The latter species took 120 h to kill the test insect. No mortality was observed in control. The suitability of this insect for multiplication of infective juveniles of EPNs was also studied. Maximum multiplication of infective juveniles was observed with *O. gingeri*, which yielded 48527 IJs/grub, followed by *Oscheius* sp. (IISR-EPN 04) (42561IJs/grub) and *Oscheius* sp. (IISR-EPN 05) (38421 IJs/grub). However, *Heterorhabditis* sp.(IISR-EPN 01) yielded the least number of IJs (10265 IJs/grub). The infectivity of *Oscheius* spp. against cardamom root grub, *B. fulvicorne* is being reported for the first time which opens up new vistas in eco-friendly insect pest management in cardamom.

P78

Efficacies of fungicides and biocontrol organisms on the suppression of rot diseases of cardamom (*Elettaria cardamomum* Maton)

M K Dhanya*, K B Deepthy, M Murugan&Anjumol K Baby

Cardamom Research Station, KAU, Pampadumpara-685553, Idukki, Kerala
*dhanya_mk2000@yahoo.co.in

Capsule and panicle rot (*Azhukal*) disease of cardamom incited by *Phytophthora meadii* has been a serious problem and a major constraint for the successful cultivation as well as production across growing areas. Several new fungicide molecules are now available to manage the disease. Keeping this in view, an attempt was made to find suitable fungicides (blue and green labeled) as well as biocontrol agents effective against the disease. Field experiments were conducted at three locations in Idukki *viz*., Pampadumpara, Mariyapuram and Vandanmedu during the monsoon season of 2013 and 2014. Among seven treatments tested, fosetyl-Al drench @1 g/l, combination of cymoxanil + mancozeb as spray and drench @2 g/l and Bordeaux mixture (1%) spray with copper oxychloride (2g/l) drench were found to be effective against the disease with less disease severity of 6.8%, 4.2% and 4.2%, respectively as against 42.9% in the untreated control. In case of biocontrol agents, though the disease severity was higher (12.86%) with *Pseudomonas fluorescens* (2%) spray with basal application of *Trichoderma viride* @100g and mycorrhiza (@50 g/plant), the yield was on par with best chemical treatments. The BC ratio's were higher for all the treatments. The combined application of *P. fluorescens* with *T. viride* and mycorrhiza or the green labeled fungicide, fosetyl-Al or blue labeled combination fungicide, cymoxanil + mancozeb or combined application of Bordeaux mixture and copper oxychloride can be advocated to control the disease effectively without affecting the ecosystem environment.

P79

Survey and occurrence of soft rot disease in ginger in Nilgiris

S Karthikeyan*, S Malathi, A Sankari, M Anand & B Anita

Horticultural Research Station, TNAU, Ooty-643001, Tamil Nadu
*hortikarthik@gmail.com

Ginger (*Zingiber officinale*) is grown in an area of 415.87 ha in Gudalur and Pandalur taluks of Nilgiris district. Soft rot of ginger is a major devastating disease caused by *Pythium aphanidermatum* and *P. myriotylum*. A survey on the occurrence and incidence of soft rot in ginger grown areas was taken up during 2014-2015. Twenty three locations *viz.,*Puliamparai, Puthur Vayal, Makkamilla, Masinagudi, 7th Mile, Salivayal, Patta Vayal, Amaikulam, Sri Madurai, Puliamparai, Mudhuguli, Atthigunna, Vazhaithottam, Devarsholai, Bitharkadu, Moyar, Singara, Thorappalli, Serumulli, Kukkimuchi, Poyampatti, Manvayal, Kamathi were surveyed in the Gudalur and Pandalur taluks, Nilgiris. The disease incidence ranged between 20.56 to 62.38 per cent. Among the locations surveyed, maximum disease incidence (62.38%) was recorded in Patta Vayal, followed by 57.64% in Devarsholai and minimum was recorded in Singara (20. 56%) of Gudalur taluk.

P80

Incidence of foliar diseases in turmeric - A survey report

C Ushamalini*, R Chitra & J Suresh

AICRP on Spices, Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*ushackadir@yahoo.co.in

Turmeric (*Curcuma longa* L.), is an important spice of daily use, grown widely in Erode and Coimbatore districts of Tamil Nadu. Pests and diseases are the major constraints in the cultivation of turmeric. Among them, leaf spot caused by *Colletotrichum capsici* and leaf blotch caused by *Taphrina maculans* are important diseases, which seriously cause yield reduction. A field survey on turmeric diseases was conducted during 2014-15 in different turmeric growing areas of Coimbatore and Erode districts. In Erode district, totally six locations were surveyed with different cropping pattern.In the case of leaf spot, maximum intensity was noticed at Avalpoondurai (32.90PDI) and the minimum intensity was recorded at Kavunthampadi (2.80 PDI) and Thandukkaranpalayam (1.00 PDI). In leaf blotch, the maximum intensity of 76.60 PDI was noticed at Avalpoondurai and minimum at Kavunthampadi (15.60 PDI). In Coimbatore district, maximum incidence of leaf blotch was noticed in Thondamuthur (42.80 PDI), followed by Devarayapuram (36.50 PDI). The leaf spot incidence was maximum in Devarayapuram (24.60 PDI), followed by Thondamuthur (6.80 PDI).

P81

Effect of different cropping systems on the intensity of foliar diseases in turmeric

P Muthulakshmi

Department of Fruit Crops,
Horticultural College & Research Institute,TNAU, Coimbatore-641003, Tamil Nadu
muthupathology@gmail.com

Turmeric (*Curcuma longa* L.) is a major spice crop of India and is widely used as food colourant besides as a raw material in pharmaceutical and textile industries. It is susceptible to many diseases caused by fungal pathogens. Among the fungal diseases, leaf spot caused by *Colletotrichum capsici* and leaf blotch caused by *Taphrina maculans* are the major diseases which reduces yield. The effect of cropping systems *i.e.,* mixed cropping as well as pure crop on the disease intensity was studied in turmeric during the year 2012-13 by conducting field survey in major turmeric growing areas of Tamil Nadu. In Coimbatore district, totally eight places were surveyed with different cropping pattern. In the case of leaf spot, the maximum intensity was noticed at Ganesapuram (58.34 PDI) and the minimum intensity was recorded at Sundarapuri (38.62 PDI). For leaf blotch, the maximum intensity of 44.60 PDI was noticed at Boluvampatty and minimum at Sundarapuri (24.60 PDI). In Erode district, totally 15 places were surveyed with different cropping pattern. Among the places surveyed, the maximum leaf spot intensity of 58.60 PDI was recorded at Poonachi and minimum at Chinthanaickanoor (44.20 PDI). The leaf blotch intensity was maximum (62.30 PDI) at Poonachi and minimum at Thimmum (32.30 PDI). In the case of leaf blotch, the maximum intensity of 54.10 PDI was observed at Kunnathur

and minimum at Perumanallur (38.42 PDI). In general, the leaf spot intensity was the minimum in turmeric grown as pure crop when compared to mixed crop with chilli and other crops in all districts.

P82

Studies on evaluation of *Curcuma longa* L. cultivars against leaf blotch (*Taphrina maculans*) and shoot borer (*Conogethes punctiferalis* Guen.)

Siddalingayya Salimath*, YK Kotikal, J Venkatesh & Revanna Revanavar

University of Horticultural Sciences, Bagalkot-591218, Karnataka
*salimath.salimath@gmail.com

A field experiment was carried out during 2012-13 to evaluate turmeric cultivars against leaf blotch (*Taphrina maculans*) and shoot borer (*Conogethes punctiferalis*). Among the cultivars, least disease incidence was observed in PTS 24 (15.62%) and Rajapuri (16.99%) while, Cuddapah was most susceptible (25.23%). Similar trend was observed with shoot borer incidence where, PTS 24 recorded significantly less incidence (9.58%) and higher incidence was recorded in Cuddapah (24.01%), followed by Belgaum Local (23.90%) and Bidar 4 (23.53%).

P83

Effect of fertigation on growth, physiology, yield and quality of nutmeg (*Myristica fragrans.* Houtt)

G Vaidehi, S Subramanian*, P Paramaguru, D Durgadevi & N Asokaraja

Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*hrstkd@tnau.ac.in

A field experiment was conducted to study the effect of fertigation with N, P and K fertilizers along with micronutrients on growth, physiology, yield and quality and to standardize the nutrient requirement through drip irrigation for nutmeg (*Myristica fragrans*) at TNAU, Coimbatore during 2011 and 2012. The study revealed that, application of 100% recommended dose of fertilizers (RDF) as water soluble fertilizers along with micronutrients through fertigation increased tree height, canopy spread, trunk girth and physiological parameters *viz*., specific leaf weight, total chlorophyll, soluble protein, carbohydrate and C/N ratio at various stages of crop growth. The activity of nitrate reductase, IAA oxidase and peroxidase were effectively accelerated due to application of 100 per cent RDF as water soluble fertilizers along with micronutrient through drip. Same treatment recorded the highest soil and leaf nutrient status *i.e.,* N, P, K, Fe, Zn and B at different stages of plant growth. The days taken to flowering, days from flowering to maturity and yield components such as, number of fruits per tree, individual fruit weight, seed weight, mace weight and pericarp weight, fruit volume and weight of the fruits were higher in 100% RDF as water soluble fertilizers along with micronutrients through drip. The quality parameters such as seed oil, mace oil, seed oleoresin, mace oleoresin, protein, fat and polyphenol content were considerably improved with the same treatment. BCR was the highest (5.98 and 6.11) in 100% RDF as water soluble fertilizers along with micronutrients through fertigation by

drip irrigation, followed by 75% RDF as water soluble fertilizers along with micronutrients (5.83 and 5.99) through drip irrigation during 2011 and 2012, respectively.

P84

Climate influences off season flowering in clove

R Richard Kennedy*, T Thangaselvabai[1]& P Senthilkumar

Regional Research Station, TNAU, Paiyur-635112, Krishnagiri, Tamil Nadu
[1]Horticultural College & Research Institute, TNAU, Periyakulam-625604, Tamil Nadu
*richkenn2006@yahoo.co.in

Radically changing climate is a major threat to biodiversity, ecosystem services and human well being. This might have lead to both positive and negative impacts on tree spices in southern peninsular India. Clove is one of the major tree spice crops largely cultivated in the hills of Kanyakumari, where it exhibits off-season bearing tendency. The genetic base is narrow and hence, no distinct varieties have been recognized. However the differences are observed in terms of tree shape, bearing habits, cropping season, yield, colour of petiole, shape and size of clove bud. Clove is normally harvested from December-February in different parts of the country. But in certain pockets of Kanyakumari district due to the different bio-geo-climatic conditions, besides the main crop it gives an off-season crop during July-August. The bimodal pattern of rainfall and its even distribution round the year, nearness to the equator, high humidity and wind velocity, even day and night temperatures, fairly high nutrient rich soil *etc*., are the major contributing factors for off-season production. The studies revealed that, 20-30 per cent of the population in the clove orchards have produced off-season crop. The flowers per inflorescence in the off-season were 10-15, number of inflorescence/shoot was 1-5 and the yield was 1-3.5 kg bud/tree.

P85

Effect of organic manure on growth and yield of coriander (*Coriandrum sativum* L.)

R Chitra*, N Shoba[1], M Mohanalakhsmi & J Suresh

AICRP on Spices, Department of Spices & Plantation Crops,
Horticulture College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[1]Coconut Research Station, TNAU, Aliyarnagar-642101, Tamil Nadu
*chitra.varadharaj@gmail.com

Coriander (*CoriandrumsativumL.*) is cultivated in Tamil Nadu either under rainfed or under irrigated conditions. Continuous and heavy application of chemical inputs results in a decline in soil microbial population, nutrient imbalance, fast depletion of soil fertility and continuous deterioration of soil physical and chemical properties and accumulation of toxic contaminants. Based on this background, a research was undertaken to study the effect of nutrient supplementation through organic manures for growth and yield of coriander. The trial was laid out at Horticultural College and Research Institute, Coimbatore with eight treatments and replicated thrice. The results revealed that, the highest plant

height was registered by the treatment T_2 [vermicompost (100%)-5t/ha]. Regarding the number of primary branches, the highest number was registered by the treatment T_4 [FYM (25%) + vermicompost (75%)]. The highest number of secondary branches (10.78) was recorded by the treatment T_4 followed by T_6 (RDF alone-chemical fertilizers) (10.63). Regarding the yield characters, number of umbels per plant ranged from 25.04 in T_2 to 29.74 in T_4. The highest number of umbellets per umbel was registered by the treatment T_3 [FYM (50%) + vermicompost (50%)] (5.81). With regard to the number of seeds per umbellets, it ranged from 27 in T_2 to 28.85 in T_4. The seed yield per plot varied from 582.59 g in T_8 (absolute control) to 948.89 g in T_7 (FYM 5 t/ha + inorganic N 50% + *Azospirillum* 1.5 kg/ha as seed treatment). The highest benefit cost ratio of 2.37 was registered by the treatment T_7 followed by T_3 (2.05).

P86

Rhizobacteria for growth promotion and yield of coriander

Ajit Kumar Singh*, Shrikant Sawargaonkar, Rishi Mahobia & N K Choubey

College of Agriculture & Research Station,Indira Gandhi Krishi Viswavidyalaya,
Boirdadar, Raigarh-496001, Chhattisgarh
*singh_ajit8@rediffmail.com

Although fungicides and growth promoting hormones offer certain degree of effectiveness in agriculture crops, often their efficacy is low over seasons due to low persistence. The plant growth promoting rhizobacteria (PGPR) are a group of rhizobacteria that colonize plant roots and increase plant growth, crop yield and also offer an attractive alternative for disease management. A trial was conducted at Indira Gandhi Krishi Viswavidyalaya, College of Agricultural and Research Station, Boirdadar Farm, Raigarh, during 2011-12 to 2013-14 to study the influence of PGPR on coriander variety, Gujrat Dhaniya 2. The rhizobacterial strains (talc based formulation), FL 18 (*Microbacterium paraoxidans*) and FK 14 (*Pseudomonas putida*) were applied as seed (@5 g kg^{-1} of seed as recommended) and soil application. The plot size was 4 x 2.7 m in randomized block design and crop was sown during the last week of October. The five treatments were, T_1: bio-formulation of FK 14 (seed & soil application), T_2: bio-formulation of FL 18 (seed & soil application), T_3: bio-formulation of FK 14 + FL 18, T_4: (seed & soil application): control (no treatment) and T_5: local popular variety (Gujrat Dhaniya 2) with four replications. The rate for soil application at the time of sowing once was 2.5 kg ha^{-1}. The data on plant height was recorded in 20 randomly selected plants at the time of maximum flowering stage.The pooled data (2011-12 to 2013-14) showed maximum seed yield (9.1 and 9.5 q/ha) and maximum plant height (63 and 65.7 cm) in the treatment when seeds were treated with rhizobacteria FK 14 and FL 18, respectively which were statistically at par.

P87

Changing climatic scenario-impact of heavy rains on growth and grain stages of coriander

S Suryakumari*, Giridhar Kalidasu & L Naram Naidu

AICRP on Spices, Horticultural Research Station, Lam, Guntur-522034, Andhra Pradesh
*surya.surepeddi@gmail.com

Coriander (*Coriandrum sativum* L.) is the most important seed spice grown in India and occupies 43.9% of total area and 46.2% of total production of seed spices in the country. As the climate change is inevitable, data collection regarding damage due to unforeseen climatic conditions is vital for better management of seed spice crops. An attempt was made to gather data on the effect of unexpected rainfall on coriander at Horticultural Research Station, Guntur during 2007-08 and 2012-13. Rainfall of at least 20 mm during November increased productivity by 41% and rainfall less than 20 mm had insignificant effect. Rainfall between 70-90 mm for few hours causes damage considerably depending on stage of the crop. Generally, the least affected showed drooping at the second day and recovered by fourth day. In less to moderately damaged plants, drooping occurred at second day and recovered moderately by a week. In the case of moderate to severe damage, drooping occurred in 24 hours and plants wilted completely by second day. In severe cases of damage, drooping occurred within 12 hours and wilted completely by 24 to 36 hours. Flowers which encountered unfavourable (rainy) weather had less number of fruits or several fruits with only one mericarp containing a seed. If heavy and continuous rains occurred during the grain filling stage, the schizocarps were severely attacked by saprophytic and pathogenic fungi (40 to 70%) and immature grains were more vulnerable to such damage. In case of rains distributed for more than 3 days, in the crop ready for harvest, *vivipary* was observed to a tune of 20% on the third day after cessation of rain in different genotypes.

P88

Influence of biofertilizers and biocontrol agent for off season leaf production of leafy coriander

C Rajamanickam & L Jeeva Jothi[1]

ICAR-Krishi Vigyan Kendra, TNAU, Ramanathapuram-623503, Tamil Nadu
[1]Horticultural Research Station, TNAU, Palur, Tamil Nadu
*manickshorti@yahoo.co.in

A field experiment on the influence of biofertilizers and biocontrol agent for off-season leaf production of leafy coriander cv. CO 4 was conducted at Horticultural College and Research Institute, Periyakulam during 2013-14. The experiment was laid out in randomized block design with eight treatments and replicated thrice. The results revealed that, combined application of 45:40:20 NPK + *Azospirillum* + *Phosphobacteria*+ *Pseudomonasfluorescens* @100 g each per bed (T_7) recorded the highest values for growth characters *viz*., plant height at 40 DAS (20 cm), plant weight at 40 DAS (9.74 g) and number of leaves per plant (7.22). The treatment T_7 resulted in minimum days for germination (5 days). With respect to yield characters, T_7 registered the highest yield per plot (4.55 kg) and estimated yield (4.5

t/ha), followed by T_4 (45:40:20 NPK + *Azospirillum* + *Phosphobacteria* @100g each) which had 4.3 kg yield per plot. The absolute control (T_8) recorded the lowest values in all the parameters recorded.

P89

Evaluation of fenugreek accessions against different ESP levels under pot condition

V P Pandey & R S Mishra*

Department of Vegetable Science,
ND University of Agriculture & Technology, Kumarganj-224229, Faizabad, Uttar Pradesh
*drramsumanmishra@gmail.com

An experiment was conducted during 2009-10 to 2011-12 to evaluate the yield performance of 10 fenugreek accessions against 10, 20, 30 and 40 ESP levels (Exchangeable Sodium Per cent) at N.D. University of Agriculture & Technology, Kumarganj, Faizabad, UP. The highest seed yield was recorded at 10 ESP level in NDM 69 in 2009-10 (5.63 g/plant), 2010-11(5.55 g/plant) and 2011-12 (5.38 g/plant). The lowest seed yield was recorded at 40 ESP level in NDM 72 (2.17 g/plant) in 2009-10, NDM 56 (2.4 g/plant) in 2010-11 and NDM 53 (2.5 g/plant) in 2011-12. The results of three years yield data showed that, NDM 69 recorded significantly higher seed yield in 2009-10 (5.63, 4.50, 3.98 and 3.12 g/plant), 2010-11 (5.55, 4.78, 4.13 and 3.12 g/plant) and 2011-12 (5.38, 4.73, 3.47 and 3.43 g/plant) at 10, 20, 30 and 40 ESP levels, respectively.

P90

Effect of phosphorus and growth regulators on growth and yield of fenugreek(*Trigonella foenum-graecum* L.)

G C Gangaram &S S Vijayapadma*

College of Horticulture, Rajgurunagar-500030, Hyderabad, Telangana
*sreevijayapsmachr@gmail.com

A field experiment was conducted during *rabi* 2010-11 to study the effect of phosphorus and growth regulators on growth and yield of fenugreek in alfisols. Three levels of phosphorus (20, 40 and 60 kg/ha), three growth regulators (NAA @20 ppm, GA_3 @50 ppm and ethrel @75 ppm) and the combination of P doses and growth regulators were evaluated. The results indicated that, among the treatments, maximum plant height (56.6 cm) was recorded with the application of 60 kg/ha P_2O_5 along with GA_3 (50 ppm) spray at 25 DAS. While pods per plant (28.5), number of seeds per pod (15.6), test weight (14.6 g) and seed yield (1670 kg/ha) and straw yield (4823 kg/ha) were maximum with the basal application of phosphorus 60 kg/ha, followed by spraying NAA (20 ppm). It is concluded that, application of phosphorus (@60 kg/ha) along with application of NAA (20 ppm) at 25 DAS was highly beneficial in alfisols.

P91

Intercropping of fennel (*Foeniculum vulgare*) with vegetables for enhancing system productivity

R S Mehta*, Balraj Singh, S S Meena, Ravindra Singh, J K Ranjan, N K Meena & S P Maheria

ICAR-National Research Centre on Seed Spices, Ajmer-305206, Rajasthan
*rsmagron@yahoo.co.in

Fennel is a long duration seed spice. Moreover, this seed spice is sown at wider spacing compared to other seed spices. Hence in the initial 70-80 days, vacant space between the rows remains idle, which leads to weed infestation. The vacant space may be utilized by growing vegetables in initial growth phase of fennel. In order to find out suitable economical intercropping system, a field experiment on intercropping of fennel with vegetables was conducted at NRCSS, Ajmer during *rabi* 2013-14. The experiment comprised of 21 treatments *viz*., fennel with five vegetables (cabbage, knolkhol, lettuce, fenugreek and French bean) in three intercropping ratios (1:1, 1:2, 2:2) along with sole fennel and sole vegetables laid in randomized block design with three replications. The result based on one year study indicated that, highest yield of fennel (890 kg/ha) recorded in sole fennel being at par with intercropping fennel with French bean in 1:1 ratio. Maximum vegetable yield was obtained in sole cabbage (13883 kg/ha) followed by sole knolkhol (9895 kg/ha). The highest fennel equivalent yield (1713 kg/ha), net return (Rs. 12700/ha) and BCR (2.87) were obtained in intercropping fennel with knolkhol in 1:2 ratio followed by intercropping fennel with knolkhol in 2:2 ratio. Thus the study indicated that, though intercropping of fenugreek and French bean is beneficial for growth and yield of fennel compared with other vegetables, in terms of equivalent yield, net return and BCR intercropping of fennel with knolkhol in 1:2 and 2:2 ratio is beneficial for realizing higher system productivity and efficient resource utilization.

P92

Impact of micronutrient application on growth, yield and micronutrient uptake in fennel (*Foeniculum vulgare* Mill.)

C B Harisha*, Sonu[1], Balraj Singh, Y Diwakar, O P Aishwath, Ravindra Singh &HonnappaAsangi

ICAR-National Research Centre on Seed Spices, Ajmer-305206, Rajasthan
[1]Department of Horticulture, MJRP College of Agriculture, MJRPU, Jaipur-302019, Rajasthan
*harisha.cb@gmail.com

A field experiment was conducted at ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan to evaluate the effect of different methods of micronutrient application on growth and yield parameters of fennel (*Foeniculum vulgare*) during October 2014 to April 2015. Results revealed that, soil application of iron 10 kg per hectare (T_2) recorded maximum plant height (227.7 cm), number of primary branches (11.7), secondary branches (19.8), total dry matter accumulation per hectare (13.39 t/ha) and seed yield per hectare (23.8 q ha^{-1}). Iron content and uptake (339.2 mg/kg and 4541.3 g ha^{-1}) was higher in T_2, manganese content and uptake (193.5 mg/kg and 2421.3 g/ha) was higher in soil application of manganese 10 kg per hectare (T_3) and zinc content and uptake (61.1 mg/kg and 762.3

g/ha) was higher in foliar application of $ZnSO_4$ (0.5%) (T_{11}). With regard to boron and copper, there was not much response in terms of growth and yield. It was concluded that, soil application of iron is the most appropriate and necessary measure to improve growth and yield in fennel.

P93

Evaluation of fungicides and bio-agents for the management of stem gall (*Protomyces macrosporus*) of coriander under field conditions

Ajit Kumar Singh*, Shrikant Sawargaonkar, N C Mandawi & P M Paraye

College of Agriculture & Research Station, IGKV,
Boirdadar, Raigarh-496001, Chhattisgarh
*singh_ajit8@rediffmail.com

Coriander (*Coriandrum sativum* L.) suffers from several diseases at various stages of crop growth. Stem gall caused by *Protomyces macrosporus* is a serious problem in coriander growing areas of Madhya Pradesh, adjoining districts of Rajasthan and Uttar Pradesh. Presently, there is no effective method for disease control, except field sanitation and timely fungicide application. Keeping this in view, a study was made to evolve an effective disease management strategy and a field experiment was carried out during 2005-2008 at Indira Gandhi Krishi Viswavidyalaya, College of Agriculture and Research Station, Boirdadar, Raigarh, Chhattisgarh with a local variety. The trial was conducted in randomized block design with seven treatments *viz*., T_1: seed treatment with commercial*Trichoderma* formulation (0.4%) + soil application,T_2:seed treatment with commercial *Pseudomonas* formulation (0.4%) + soil application,T_3:seed treatment with carbendazim (0.2%) + spray at 45, 60 & 75 DAS (0.2%), T_4:seed treatment with blitox-50 (0.2%) + spray at 45, 60 & 75 DAS (0.2%), T_5:seed treatment withhexaconazole(0.2%) + spray at 45, 60 & 75 DAS (0.2%), T_6: seed treatment with propiconazole(0.2%) + spray at 45, 60 & 75 DAS (0.2%) and T_7: control.On the basis of pooled data (2010-11 to 2012-13), seed treatment + spray with hexaconazolehad 6.90% disease intensity and 8.53 q/ha yield and seed treatment + spray with propiconazolehad 7.6% disease intensity and 8 q/ha yield. Both treatments were statistically at par. As conclusion, hexaconazole or propiconazole seed treatment (0.2%) and spray of the same at 45, 60 and 75 days of sowing were found be effective in managing stem gall of coriander.

P94

Use of new generation fungicides for the management of coriander powdery mildew

C Ushamalini*, S Nakkeeran[1]& J Suresh

Department of Spices & Plantation Crops,
[1]Department of Plant Pathology,
Horticultural College & Research Institute,TNAU, Coimbatore-641003, Tamil Nadu
*ushackadir@yahoo.co.in

Coriander is an important culinary spice of daily usage as green leaves and seed. In India, It is grown widely in Rajasthan, Gujarat, Madhya Pradesh, Haryana, Punjab, Uttar Pradesh, Bihar and Tamil Nadu. In Tamil Nadu, the coriander growing areas include Coimbatore, Trichy, Cuddalore, Perambalur, Tirunelveli, Ramnad, Virdhunagar and Thoothugudi. This crop is highly prone to the attack of several diseases, among them powdery mildew caused by *Erysiphe polygoni,* is an important disease, resulting in yield losses up to 35-40%. A field trial was laid out during *rabi* 2014-15 to test the efficacy of new generation fungicides. Among the fungicides tested, the powdery mildew incidence was 5.14 PDI in propiconazole (0.15%) sprayed plants, followed by 11.67 PDI in tebuconazole (0.15%) and difenconazole (0.05%) sprayed plants. While in control, the incidence was 91.55 PDI. The propiconazole sprayed plants also recorded the highest yield of 663.3 kg/ha, while in control, the yield was 556.1 kg/ha. The results revealed that, spraying with propiconazole (0.15%) is highly effective for the management of powdery mildew.

P95

Bio-efficacy of different insecticides against sucking pests infesting fenugreek under North Gujarat condition

B G Prajapati* & A U Amin

Seed Spices Research Station, SDAU, Jagudan-382710, Gujarat
*prajapatibg58@gmail.com

Fenugreek (*Trigonella foenum-graceum* L.), popularly known as Methi, is a major seed spice grown in India for domestic and export purposes. Among various insect pests, fenugreek aphid, *Acyrthosiphon pisum* and fenugreek leaf hopper, *Empoasca spinosa* affect yield and quality adversely. The information on bio-efficacy of insecticides against sucking pests infesting fenugreek is scanty. Therefore, the present experiment on bio-efficacy of different insecticides against sucking pests was taken up during *rabi* 2012-13 at Seed Spices Research Station, S.D. Agricultural University, Jagudan, Gujarat. The lay out was made in randomized block design with ten treatments and four replications with the variety Gujarat Fenugreek 2. The treatments consisted of two foliar applications with carbosulfan 25 EC @0.05%, acetamiprid 20SP @0.004%, clothianidin 50WDG @0.025%, thiamethoxam 25WG @0.0084%, imidacloprid 17.8SL @0.005%, thiacloprid 21.7SC @0.024%, acephate 75 SP @0.075%, neem-based formulation 1500 ppm @3 ml per litre, *Verticillium lecanii* 1.15WP @4 g/litre and untreated control. The population of predatory coccinellids was also recorded. Among various insecticides, thiamethoxam exhibited 0.15 and 0.05 aphid index at three and seven days after second spray, respectively. Similarly, the population of leaf hopper also registered 0.69 and 0.1 per 3 leaves at three and seven days after second spray, respectively with thiamethoxam. The treatments of *V. lecanii* (1.55/plant), neem-based formulation (1.14/plant) and thiamethoxam (1.04/plant) exhibited higher population of predatory coccinellids, whereas, clothianidin, carbosulfan and imidacloprid proved toxic, which registered 0.78%, 0.89% and 0.89%, respectively. The plots treated with thiamethoxam recorded highest seed yield (1567 kg/ha) but was statistically at par with acetamiprid (1484 kg/ha). Unprotected plots had the lowest seed yield (822 kg/ha).

P96

Screening of cumin germplasm against powdery mildew caused by *Erysiphe polygoni* DC.

N R Patel*, K D Patel & A M Amin

Seed Spices Research Station, SDAU, Jagudan-382710, Gujarat
*nrp_dax@yahoo.com

India is the leading country in the world in cultivation, production and consumption of seed spices in general and cumin (*Cuminum cyminum* L.)in particular. Diseases *viz*., blight, powdery mildew and wilt are the major reasons for low productivity in cumin. Hence, an experiment was undertaken to identify the sources of resistance to cumin powdery mildew (*Erysiphe polygoni*) under natural condition at Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Gujarat. A total of 28 promising entries were screened with three checks *viz*., GC 2, GC 3 and GC 4. Among twenty eight entries/varieties screened, none were found immune or resistant against the disease. However, minimum per cent disease intensity at maturity was observed in JC 2000-53 (31.14%), JC 2000-46 (31.84%) and JC 2000-54 (33.47%) whereas, JC 2000-55 was found to be the most susceptible, with the highest disease severity (55.21%).

P97

Effect of growth regulators and boron on growth and yield of summer chilli cv. Lam 353

P Kiranmai, K Uma Jyothi* & K Usha Kumari

Horticultural College & Research Institute, Dr. YSR HU,
Venkataramannagudem,West Godavari-534101, Andhra Pradesh
*drumajyothik@gmail.com

Chilli is one of the most important spice crops in India and Andhra Pradesh is the largest producer in the country. Growth promoters and micronutrients have significant effect on flowering and fruit set in chilli. Hence, the present investigation entitled, effect of growth regulators and boron on yield of summer chilli in cv. Lam 353 was carried out in the year 2013 during summer season at Horticultural College and Research Institute, Venkataramannagudem, West Godavari, Andhra Pradesh. The experiment was taken up with 16 treatments in RBD, replicated thrice involving two growth regulators *viz.,* NAA @10 ppm & 20 ppm, 4-CPA @25 ppm & 50 ppm and micronutrient boron @0.05

&0.1% individually and in combinations, sprayed at 60, 90, 120, 150 and 180 days after sowing. Among the treatments, plants sprayed with NAA 20 ppm + boron 0.05% recorded the maximum plant height (83.33 cm), plant spread (137.33 cm), number of primary branches (17), minimum number of days to 50% flowering (63 days), highest fruit set percentage (30.33%) and maximum number of fruits per plant (124). Significantly higher yields were recorded with application of NAA 20 ppm + 0.05% boron and NAA 20 ppm application over control and these two treatments were on par with each other. The highest yield per plant (263.5 g) with an estimated yield of 145.9 q/ha was observed in the plants sprayed with NAA 20 ppm + boron 0.05% followed by NAA 20 ppm application (260.3 g, 141.69 q/ha) which were found on par with each other and significantly superior to control.

P98

Effect of mulching on weed density and fruit yield of chilli (*Capsicum annuum* L.)

V A Sathiyamurthy& T Arumugam*

Department of Vegetable Crops,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*vegetables@tnau.ac.in

An experiment was conducted in chilli (*Capsicum annuum* L.) with hybrid CO 1 to find out the effect of mulching on yield, yield attributing characters and weed density during 2013-15 at the Department of Vegetable Crops, TNAU, Coimbatore. The experiment was laid out in RBD with seven treatments *viz*., no mulch, organic mulch @6 t/ha, organic mulch @9 t/ha, organic mulch @12 t/ha, black/silver polythene (double coated, 30 microns), black/white polythene (double coated, 30 microns), black polythene (30 microns) in three replications. The results showed that, number of fruits/plant (213.6), green fruit weight (965 g/plant), green fruit yield (303 q/ha) were maximumwith organic mulch @12 t/ha followed by organic mulch @9 t/ha with green fruit yield of 292.3 q/ha. The lowest weed density (12/sq.m) was recorded with black/silver polythene followed by black/white polythene mulch (13/sq.m).

P99

Effect of organic sources of nutrients on growth parameters and seed yield in chilli cv. PKM 1

V Marthandan* & K Sundaralingam

Department of Seed Science & Technology,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*vishvamarthandan56@gmail.com

An experiment was conducted at Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore in chilli cv. PKM 1 with an objective to evaluate the effect of organic sources of nutrients on growth parameters and seed yield. Seeds bio-primed with *Azospirillum* (15% for 6 h) and untreated seeds were sown in pro-trays and transplanted to the main field 35 days after sowing. Seeds

bio-primed with *Azospirillum* had better establishment and growth compared to unprimed seeds. Irrespective of main plot treatments, plant height was maximum at 30, 60 and 90 DAT, 34.6 cm, 57.3 cm and 69.7 cm, respectively with recommended dose of fertilizer (60:60:30 kg NPK ha^{-1}), followed by 100% vermicompost (32.2 cm, 55.3 cm and 69.1 cm, respectively) of sub-plot treatments. Among the organic treatments, conversion efficiency (79.01%), fruit yield (2097 kg/ha) and seed yield (196.1 kg ha^{-1}) were maximum with 100% vermicompost. It is concluded that, 100% vermicompost is the best organic source for chilli seed production, compared to other sources of organic nutrients and better seedling establishment can be achieved through bio-priming of seeds with *Azospirillum.*

P100

Effect of different sources and levels of potassium on physiological parameters of paprika (*Capsicum annuum* var. *longam*) cv. KTPL 19 under drip fertigation system

G Sathish*,V Ponnuswami, I Geethalakshmi[1]& M S Marichamy[2]

Horticultural College & Research Institute, TNAU, Periyakulam-625604, Tamil Nadu
[1]Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[2]PAJANCOA, Karaikal UT of Puducherry-3, Tamil Nadu
*gskspice@gmail.com

Paprika (*Capsicum annuum* var. *longam*) is one of the important natural food colourants gaining importance in international spice trade. Investigations were carried out in paprika cv. KTPL 19 at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, TNAU, Coimbatore to study the influence of drip fertigation on physiological traits. The experiment was conducted for two seasons *viz.*, season I (June 2007-January 2008) and season II (July 2008-February 2009) to get the concurrent result. The experiment was laid out in randomized block design, replicated thrice with seven treatments. Observations on physiological traits *viz.,* dry matter production, leaf area index (LAI), total chlorophyll content and relative water content (RWC) were recorded from randomly selected plants and the data were statistically analyzed. From the study it was observed that, the crop paprika responded well to the fertigation treatments. Application of 100% recommended dose of fertilizers (RDF) as MAP, Multi-K and SOP through drip irrigation registered the highest values for dry matter production (134.12 g $plant^{-1}$), LAI (0.73), total chlorophyll content (2.15 mg g^{-1}) and RWC (66.88 per cent) at harvesting stage. It was followed by the treatment T_6 and T_4 during both season I and season II.

P101

Evaluation of pre and post emergence herbicides for their efficacy and selectivity in onion

M Venkateswar Reddy, K Uma Jyothi*, P Shyam Sunder Reddy, K Sasikala & K Uma Krishna

Horticultural College & Research Institute, Dr. YSR HU,
Venkataramannagudem, West Godavari-534101, Andhra Pradesh
*drumajyothik@gmail.com

An experiment wasconducted at Horticultural College and Research Institute, Venkataramannagudem, W.G, A.P during *rabi* 2011-12 and 2012-13 to study the effect of pre and post-emergence herbicides on growth and yield of onion. In onion, weed management practices exerted significant effect on density of weeds *viz*., grasses, sedges, broad leaved weeds, total weeds and dry matter of weeds at various stages of crop growth. These attributes were found to be minimum with hand weeding at 20, 46, 60 DAT followed by application of pre-emergence herbicides *i.e.,* pendimethalin @0.75 kg a.i/ha or oxyfluorfen @0.125 kg a.i/ha coupled with quizalofop ethyl @75 g a.i/ha as post-emergence application which were found to be on par with one another. In onion, growth attributes *viz*., number of leaves per plant, LAI, plant dry matter and yield attributing characters *viz*., average bulb weight, bulb diameter, neck diameter, bulb length were found to be higher with application of pendimethalin as pre-emergence spray in conjunction with quizalofop ethyl as post-emergence spray next to free-hand weeding at 20, 40 and 60 DAT. In both the years (2011, 2012), though highest yield was recorded with weed free plot (hand weeding) with 18.89 t/ha and 19.19 t/ha respectively, it was found on par with the plots applied with pendimethalin (17.75 t/ha) or oxyfluorfen (16.87 t/ha) coupled with quizalofop ethyl as post-emergence application. Quality parameters *viz*., total soluble solids (TSS), sprouting (%) and rotting (%) in onion were not affected due to herbicide application.

P102

Influence of plant density and method of planting on performance of garlic var. AAS 2

Dudhate Mahesh* & J S Hiremath

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, Arabhavi-591218, Karnataka
*maheshdudhate@gmail.com

A field experimentwas conducted during 2014-2015 atKittur Rani Channamma College of Horticulture, Arabhavi to study theinfluence of plant density and method of planting on performance of garlic variety AAS 2. The field trials were laid out in split plot design with two main (M:planting method) and five sub-treatments (S:plant density), replicated thrice. Significant differences were observed in plant growth parameters *viz*., plant height, number of leaves per plant, leaf length and breadth and collar diameter. Significant differences were also observed with yield parameters like weight of bulbs, bulb diameter, weight of cloves and bulb yield per hectare. Significantly higher bulb yield (6.68 t/ha) was recorded in raised bed and least bulb yield (5.73 t/ha) was recorded in flat bed. Significantly higher bulb yield (8.83 t/ha) was recorded by the treatment S_1 (15 cm x 2.5 cm) followed by S_4 (15 cm x 10

cm) which recorded 6.86 tonnes per hectare compared to the lowest (2.08 t/ha) recorded in S_5 (broadcasting). Among interaction effect, significantly higher bulb yield (9.86 t/ha)was recorded by S_1M_1 followed byS_1M_2 (7.81 t/ha) and S_4M_1 (7.24 t/ha). The minimum yield was observed in the treatment S_5M_2 (1.84 t/ha). Higher cost of cultivation was accounted in the treatment S_1 (Rs. 156160)followed by S_2 Rs. 123451). Highest net returns and benefit cost ratio was recorded by raised bed (Rs. 305577 and 2.50), compared to crop sown in flat bed (Rs. 256451 and 2.25). Among interaction effects, B:C ratio was higher in S_4M_1 (3.62) followed by S_4M_2 (3.38) and lowest was recorded by S_5M_2 (0.07).

P103

Effect of planting time on growth and yield in garlic (*Allium sativum*) cv. Jamnagar

G Vidya*, M Padma, M Rajkumar & T Ramesh

College of Horticulture, Rajendranagar-500030, Hyderabad, Telangana
*vidyagunda@gmail.com

Garlic (*Allium sativum*) a member of *Alliaceae*, is the second most widely used and cultivated bulb crop after onion. It is used both as spice and vegetable. Inspite of its wide application and utility, not much organized research work has been done on agro-techniques to enhance the production and productivity in general in Telangana and South Telangana zone, in particular. Usually, the farmers go for garlic planting during the period between September to October which gives optimum yield under normal *rabi* season. Early sowing of garlic on last week of September significantly increased the yield and yield contributing characters. Hence, present study was undertaken to evaluate and standardize the date of planting on growth and yield of garlic. A field experiment was conducted during late *rabi*of 2011-2012 at College ofHorticulture, Rajendranagar, Hyderabad. There were fourdifferent dates of planting *viz*., D1 (1^{st} November), D2 (15^{th}November), D3 (1^{st} December) and D4 (15^{th} December). The experiment was laid out in split plot design with 3 replications. The results revealed that, planting on 1^{st} November recorded significantly higher growth parameters like plant height, plant girth, number of leaves/plant, fresh weight and dry weight of leaves, maximum yield (88.75 q/ha), bulb weight, clove weight and number of cloves per bulb. Delayed planting from November 1^{st} onwards resulted in reduced yields chronologically in later plantings.

P104

Influence of vermicompost on growth, yield attributes and quality of garlic (*Allium sativum* L.)

S Ajithkumar*, N K Hegde, Ravi Pujari& H C Vikram

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*ajithkumar.592@gmail.com

An experiment was carried out at KRC College of Horticulture, Arabhavi, Karnataka during *rabi*2012 and 2013 to study the response of garlic to different levels of vermicompost. The experiment consisted of seven treatments with varying doses of vermicompost along with the Recommended Dose of Fertilizer (RDF). Significantly higher mean plant height, number of leaves per plant, leaf length, leaf breadth, collar diameter, fresh and dry weight were recorded by the treatment applied with 100 per cent RDN through vermicompost (60.48 cm, 6.97, 36.92 cm, 9.95 mm, 8.13 mm, 24.42 g and 11.01 g, respectively). Significantly higher mean weight of bulb, mean bulb diameter, mean weight of cloves per bulb, mean number of cloves per bulb and mean bulb yield (8.77 g, 26.66 mm, 21.25, 7.87 g, 3.45 kg and 7.67 t ha^{-1}, respectively) and higher sulphur content of bulb (0.043%) were obtained with 100 per cent Recommended Dose of Nitrogen (RDN) through vermicompost. It is concluded that, application of 100 per cent RDN through vermicompost is optimum for better growth, development and for getting higher returns in garlic.

P105

Effect of integrated nutrient management on yield and quality of garlic(*Allium sativum* L.)

M Eragegowda*, J Venkatesh, D Hareesh& Y Ravi

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*eragegowda144@gmail.com

An investigation was conducted at KRC College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkot, during *rabi*2014-2015 to study the effect of integrated nutrient management on yield and quality of garlic. The experiment was laid out in randomized block design with eleven treatments and replicated thrice. The result indicated that, the highest bulb yield per plot (3.9 kg) andyield per hectare (10.39 t/ha). Higher sulphur concentration of bulb (0.043%) was recorded with the application of 75% RD N + RD PK + RD FYM + *Azotobacter beijerinckii* + PSB + *Trichoderma viride*.

P106

Effect of integrated nutrient management (INM) practices on yield and quality of garlic

V P Santhi, N Selvaraj[1]& M Jawaharlal*

Horticultural College & Research Institute for Women, TNAU, Trichy-620009, Tamil Nadu
[1]Horticultural Research Station, TNAU, Ooty-643001, Tamil Nadu
*sohort@tnau.ac.in

An experiment was conducted to study the effect of INM practices on the yield and quality of garlic at Horticultural Research Station, Nanjanadu, Ooty during 2010-2014. The experiment consisted of nine treatments *i.e.*, T_1 (control)-local recommendation, T_2-100:50:50:50 kg NPKS + farm yard manure @20 t/ha, T_3-75:40:40:40 kg NPKS + FYM @15 t/ha, T_4-75:40:40:40 kg NPKS + poultry manure (PM) @7.5 t/ha, T_5-75:40:40:40 kg NPKS + vermicompost @7.5 t /ha, T_6-75:40:40:40 kg NPKS + FYM @7.5 t/ha + PM @3.75 t/ha, T_7-75:40:40:40 kg NPKS + FYM @7.5 t/ha + VC @3.75 t/ha, T_8-75:40:40:40 kg NPKS + @3.75 t/ha + VC @3.75 t/ha and T_9-75:40:40:40 kg NPKS + FYM @5 t/ha + PM @2.5 t/ha + VC @ 2.5 t/ha. All the organic manures along with a common dose of 5 kg each of *Azospirillum* and PSB per hectare were applied as basal dose to all the treatments except control. The results revealed that, T_9 had significantly higher plant height (68.7 cm), number of leaves (8.17), neck thickness (3.47 cm), polar diameter (40 mm), equatorial diameter (36.8 cm), average weight of 10 bulbs (203.3 g) and also the highest number of ‘A’ grade (32.6%) as well as ‘B’ grade (51.3%) and the least ‘C’ grade bulbs (16.1%). T_9 also recorded the highest marketable yield (8.52 t/ha), total yield (10.61 t/ha), followed by T_6 (9.72 t/ha) and highest population of bacteria, fungi and actinomycetes in the soil at harvesting compared to bulbing stage. The highest B:C ratio was recorded in T_9 (3.95), followed by T_6 (3.36).

P107

Response of garlic (*Allium sativum* L.) to organic and inorganic fertilizers

B R Kumara, Shankargoud Patil[1]& K B Yogishkumar*

Department of Plantation & Spices, TNAU, Coimbatore-641003, Tamil Nadu
[1]Dept of PMA, College of Horticulture, Bagalkot, Karnataka
*yogish.siddu993@gmail.com

Field experiments were conducted during *rabi* 2011-2012 at Kittur Rani Channamma College of Horticulture, Arabhavi to study the effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic. Significant differences were observed among the treatments with respect to plant height, number of leaves per plant, leaf length and breadth and collar diameter with organic and inorganic sources of nitrogen. Significant differences were also observed with respect to yield parameters like weight of bulbs, bulb diameter, weight of cloves and bulb yield with nitrogen sources. Significantly higher bulb yield (5.36 t/ha) was recorded in T_8 (100 % RDN through vermicompost) and least bulb yield (4.17 t/ha) was recorded in T_3 (75% RDN through FYM + 25% RDN through urea). Highest B:C ratio (2.71) was recorded in T_9 (100% RDF) and least (1.64) was recorded inT_7 (75% RDN through VC + 25% RDN through urea).

P108

Defense related impact of chilli seed treatment with *Trichoderma viride* and carbendazim against *Aspergillus flavus*

Mohammed Faisal Peeran* & Prabakar Kuppusami

Department of Plant Pathology, Centre for Plant Protection Studies,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*mohammedfaisal@spices.res.in

Chilli fruits are commonly contaminated by Eurotimycetes fungus, *Aspergillusflavus* (Eurotiales: Trichomaceae). This study was carried out to investigate the changes in defense enzymes upon seed treatment with *Trichoderma* and carbendazim challenged against *A. flavus*. Initially the seeds were treated with 0.25% spore suspension of *A. flavus*, which was followed by treatment with *T. viride* at three different concentrations *viz.,* 2g/kg, 4g/kg and 6g/kg of seeds and with carbendazim at 2g/kg of seeds. Changes in the activity ofdefense enzymes *viz.*, peroxidise (PO), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL) and catalase (CAT) were observed at different days after germination. The PO activity significantly increased in the seedlings treated with *T. viride* at 6g/kg with change in absorbance value 1.76 followed by treatment with *T. viride* at 4g/kg with change in absorbance value of 1.74 at 470 nm per minute per gram of fresh tissue on 11th day. The PPO activity significantly increased in the seedlings treated with *T. viride* at 6g/kg with change in absorbance value of 3.97 followed by treatment with *T. viride* at 4g/kg with change in absorbance value of 3.87 on 11th day. The catalase activity significantly increased (1.50) in the seedlings treated with *T. viride* at 6g/kg followed by treatment with *T. viride* at 4g/kg (1.47) on 11th day. The PAL activity significantly increased (5.85) in the seedlings treated with *T. viride* at 6g/kg followed by treatment with *T. viride* at 4g/kg (5.8) on 11th day.

P109

Influence of weather parameters on population dynamic of whitefly and incidence of leaf curl disease of chilli

A N Chaubey & R S Mishra*

Department of Plant Pathology,
ND University of Agriculture & Technology, Kumarganj, Faizabad-224229, Uttar Pradesh
*drramsumanmishra@gmail.com

Chilli (*Capsicum annuum* L.) is an important spice crop cultivated all over the world. The importance of chilli leaf curl disease has been recognized for many years, wherever chilli crop is grown. It is one of the most devastating diseases of cultivated chilli and transmitted through the vector whitefly (*Bemisia tabaci*) under favourable environmental conditions. An experiment was carried out at N.D. University of Agriculture & Technology, Kumarganj, Faizabad, UP during 2014 and 2015 from February to May to study the relationship between weather, whitefly population and the disease incidence. The first appearance of whitefly was recorded at 10th standard week and rapid progress of white fly population was recorded from 11th standard week to 17th standard weeks in 2014 and 18th week in 2015. The

white fly population had significant positive correlation with minimum and maximum temperature, whereas rainfall and relative humidity had non-significant negative correlation during both the years. Disease incidence of chilli leaf curl had positive significant correlation with white fly population (r=0.93 in 2014 and r=0.89 in 2015). The maximum per cent leaf curl increase was observed in 19th standard week when the white fly population was highest in the field.

P110

Effect of organic and inorganic pesticides on major insect, mite pests and natural enemies of chilli (*Capsicum annuum* L.)

L Hanumantharaya*, A Asma & Kundaty Deepika

Department of Horticultural Entomology,
University of Agricultural & Horticultural Sciences, Shivamogga-577225, Karnataka
*lhraya@rediffmail.com

An experiment was carried out in open field under sprinkler irrigated conditions to evaluate pesticides in capsicum at Sabbenahalli, Mudigere, Chikmagalur, Karnataka during summer 2013-14. The experiment was laid out in randomized complete block design with twelve treatments and three replications. In experimental plots, all the recommended agronomic practices were followed except plant protection measures *viz*., insecticides and acaricides. Among the different treatments, two sprays of imidachloprid 36 SL @0.3ml/ l at 2 & 5 WAT, two sprays of flubendiamide 480 SC @0.2 ml/l at 7 & 11 WAT, one spray of fenazaquin 10 EC @1ml/l at 9 WAT recorded lowest population of insect and mite pests with highest net returns and cost benefit (C:B) ratio, which was followed by two sprays of imidachloprid 17.8 SL @0.3ml/l at 2 & 5 WAT, two sprays of spinosad 45 SC @0.25 ml/l at 7 & 11 WAT and one spray of fenazaquin 10 EC @1ml/l at 9 WAT. In the present study, new insecticides and acaricides were used for tackling the insect and mite pests which were very effective against the chilli pests and safer to the beneficial insects.

P111

Population dynamics of major insect and mite pests of capsicum and their natural enemies under hill zone of Karnataka

Kundaty Deepika, A Asma*, L Hanumantharaya & M S Brunda Kumari

Department of Horticultural Entomology,
University of Agricultural & Horticultural Sciences, Shivamogga-577225, Karnataka
*asma.bilagula@gmail.com

Investigations were carried out on population dynamics of insect, mite pests and natural enemies of capsicum during summer 2013 at Sabbenahalli, Mudigere taluk, Chikmagalur, Karnataka. For this experiment, 35 days old seedlings of capsicum hybrid Indra were transplanted in the main field of 20 m^2 area with a spacing of 60 cm × 45 cm. The recommended package of practices was followed except the plant protection measures *viz*., insecticides and acaricides. The peak incidence of thrips,

Scirtothrips dorsalis and LCI due to thrips, mites, *Polyphagotarsonemus latus* and LCI due to mites was noticed during the third week of April and third week of May, respectively. Thrips correlated significantly and positively with maximum temperature (r=0.542) and negatively with rainfall (r=-0.581) whereas, mites exhibited significant and positive correlation with maximum and minimum relative humidity (r=0.580 & r=0.512, respectively) and significantly negative correlation with rainfall (r=-0.501). The peak incidence of *Helicoverpa armigera*and *Spodoptera litura*were noticed during the first week of June and exhibited non-significant positive correlation with maximum and minimum relative humidity, maximum and minimum temperature and rainfall. Further, the peak activity of coccinellids, chrysopids and spiders were noticed during the third week of April, third week of May and fourth week of May, respectively and it was non-significant and positively correlated with maximum and minimum temperature, maximum and minimum relative humidity and rainfall.

P112

Influence of organic manures and inorganic fertilizers on insect and mite pests of capsicum under hill zone of Karnataka

A Asma*, Kundaty Deepika, L Hanumantharaya & M S Brunda Kumari

Department of Horticultural Entomology,
University of Agricultural & Horticultural Sciences, Shivamogga-577225, Karnataka
*asma.bilagula@gmail.com

The investigations on capsicum, *Capsicum annuum* var. *grossum* pests were carried out mainly on influence of organic manures and inorganic fertilizers on insect and mite pest population under paddy fallow area during the year 2013-14 at Sabbenahalli, Mudigere taluk, Chikmagalur, Karnataka. The nutrition managementcomprised of reduction in recommended dose of N and application of organic manures. Seedlings of capsicum variety Indira were raised in nursery and 35 days old seedlings were transplanted in plot size of 3 m × 3 m with spacing of 60 cm × 45 cm during 1st week of March 2013. The experiment was laid out in randomized block design with 11 treatments and 3 replications. The eleven treatments tested in field conditions were supplemented with organic manures along with inorganic fertilizers at different doses. Among the different treatments, NPK 100% + recommended package of practices proved to be the better management tactic. Whereas, among the organics amended treatments, 50% N + 100% PK + 2500 kg/ha VC and 50% N + 100% PK + 500 kg/ha NC were found to be effective, as it registered significantly lower population of insect and mite pests and leaf curl index with highest net returns and C:B ratio. Such crop environment modification might help build-up of natural enemies, resulting in reduced activity of pests on crops amended with vermicompost and neem cake at recommended rates.

P113

Ecofriendly pest management approaches for the management of capsicum pests through organics and safer insecticides

L Hanumantharaya*, A Asma, Kundaty Deepika & M S Brunda Kumari

Department of Horticultural Entomology,
University of Agricultural & Horticultural Sciences, Shivamogga-577225, Karnataka
*lhraya@rediffmail.com

An experiment was carried out in open field with sprinkler irrigated conditions for ecofriendly management of capsicum pests at Sabbenahalli, Mudigere taluk, Chikmagalur, Karnataka during summer 2013-14. The experiment was laid out in randomized block design with 11 treatments and 3 replications.The treatments were imposed at the time of transplanting.Among the superimposed treatments, one spray each of nimbecidine 1500 ppm @3 ml/l at 3 WAT, spinosad 45 SC @0.25 ml/l at 8 WAT, NSKE @5% at 11 WAT and abamectin 1.9 EC @0.5 ml/l on 13 WAT, 50% N + 100% PK + 2500 kg/ha VC and 50% N + 100% PK + 500 kg/ha NC were found to be better in management of insect and mite pests and was on par with NPK 100% + RPP with highest net returns and C:B ratio due to the additive effect caused by the interaction of both organics applied to the soil and superimposed safer molecules. In the present findings, organic treatments along with the super imposition of safer molecules were found safer to the natural enemies *viz.,* chrysopids, coccinellids and spiders, which might be due to non-toxic effect.

P114

Garlic virus disease incidence in relation to thrips population

S Malathi, M Anand & B Anita

[1]Horticultural Research Station, TNAU, Ooty-643001,Tamil Nadu
[2]Department of Plant Pathology,
Tamil Nadu Agricultural University, Coimbatore-641003Tamil Nadu
*malathi_agri@rediffmail.com

Garlic (*Allium sativum* L.) is known to be infected with multiple species of viruses, known as “garlic viruscomplex”. So far, sixteen major viruses belonging to the genera, *Potyvirus, Allexivirus, Carlavirus, Tospovirus* (*Iris yellow spot virus*) and *Potexvirus* have been reported to affect garlic. The *Iris yellow spot virus* is transmitted by thrips (*Thrips tabaci*) and the population is directly proportional to viral disease incidence. In this context, a survey was conducted during 2014-2015 in Nilgiris to study the viral disease incidence in garlic. The incidence of viral disease ranged between 15.25 to 46.84 per cent. Among thirty locations surveyed in Nilgiris, maximum disease incidence (46.84%) was recorded in Kothumudi-Thuneri, Ooty, where thrips population was 31.28%.

P115

Standardization of potting media for sacred basil (*Ocimum sanctum* L.)

L Nalina*, R Sumathi, K Rajamani & R M Vijayakumar

Department of Medicinal & Aromatic Crops,
Horticultural College & Research Institute,TNAU, Coimbatore-641003, Tamil Nadu
*lnalina_hort@rediffmail.com

Ocimum sanctum belonging to the family Lamiaceae, commonly known as Tulsi is praised and worshipped for its incomparable ethnic and cultural values. An experiment was conducted in the Department of Medicinal and Aromatic Crops, HC & RI, TNAU, Coimbatore to standardize the potting media for sacred basil under pot culture condition. The experiment consisted of six treatments and four replications and was laid out in completely randomized design (CRD). Seedlings were raised separately for each treatment in pro-trays. 30 days old seedlings were transplanted in the pots filled with respective treatment media. Growth parameters *viz*., plant height, plant spread, number of branches, internodal length, leaf length and breadth were measured at 30, 60 and 90 days after planting. The herbage was harvested at 90 days after planting leaving 10 cm at the base. Leaves were removed and fresh weight was recorded. Leaves were dried and subjected to solvent extraction and the dry extract yield was recorded. Eugenol content was estimated using GC-MS. Among the different treatments, the treatment, T_5 (red soil + sand + FYM + vermicompost along with Azosphosmet and VAM) recorded maximum growth and yield parameters. Eugenol content was also maximum in the same treatment.

P116

Modeling individual fruit volume of Malabar tamarind (*Garcinia gummi-gutta* (L.) Roxb.) based on fruit length and diameter measurements

M Kishor Kumar*, R Senthil Kumar & V Sankar

ICAR-IIHR, Central Horticultural Experimental Station,
Chettalli, Kodagu-571248, Karnataka
*mkkhorti@gmail.com

Garcinia gummi-gutta, commonly known as *G. cambogia*, Brindle berry, Malabar tamarind and Kudam puli is native to Indonesia. *G. gummi-gutta* is used in cooking, including in the preparation of curries. The precise estimation of fruit volume is very important for many experimental comparisons like yield prediction, relationship between fruit expansion rate and susceptibility to diseases, physiological or pathological disorders. Various combinations of measurements and various models relating to length and diameter to volume have been developed for several fruit and vegetable crops, while the information on fruit volume estimation in Malabar tamarind is lacking. In this research, we developed a model relating to Malabar tamarind fruit length and diameter to its volume using regression analysis. Investigation was performed during 2014 and 2015 under open field conditions to test whether a model could be developed to estimate fruit volume using linear measurements of fruits. Regression analysis performed by keeping fruit volume as dependent variable and fruit length and diameter as

independent variables disclosed several models that could be used for estimating the volume of individual Malabar tamarind fruits. A regression model having L x D as the independent variable (FV=-59.65+4.56* (Length x Diameter)) provided most accurate (R^2=0.93), (MSE=85.07) estimate of Malabar tamarind fruit volume. In validation experiment performed during the year 2015, model having product of length and diameter of fruits from other genotypes revealed that, the correlation between calculated and measured fruit volume was very high (r^2=0.93). Therefore, this model can be used for precise estimation of fruit volume of Malabar tamarind in successive manner without excision of fruits from plants.

P117

Effect of organic manures and biofertilizers on growth attributes and yield of black nightshade (*Solanum nigrum* L.)

M Ammaan& S Subramanian

Department of Spices, Plantation, Medicinal & Aromatic Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*hortiammu@gmail.com

Solanum nigrum L., commonly known as black night shade (*Solanaceae*) is an important medicinal plant which has tremendous medicinal value. A field experiment was carried out at the Department of Medicinal and Aromatic Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2012-13 to study the effect of organic manures and biofertilizers on growth attributes and yield characteristics of black night shade. It was noticed that, soil application of vermicompost (6 t ha^{-1})+ Azophosmet (2 kg ha^{-1})+ foliar spray of PPFM (1%) recorded the maximum plant height (52.86 cm, 74.65 cm and 80.98 cm), canopy spread NS (33.26 cm, 40.51 cm and 46.97 cm), EW(32.08 cm, 40.55 cm and 46.34 cm), number of branches (3.83, 4.42 and 5.51) at 30, 60 and 90 days after sowing and the yield also was maximum in the same treatment (19.88 t ha^{-1}).

P118

Studies on standardization of integrated nutrient management for improved growth, yield and quality of *Phyllanthus amarus*

S Padmapriya* & K Rajamani

Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*spadmapriyaa@yahoo.co.in

An experiment was conducted to determine the effect of organic amendments and bio-stimulants on growth, yield and quality parameters of*Phyllanthus amarus* at Horticultural College & Research Institute, TNAU, Coimbatore. The experiment was laid out in split plot design with three replications. The main plot included various combinations of organic manures and the sub-plot consisted of foliar application of bio-stimulants *viz.,* panchagavya, humic acid and Manchurian mushroom extract. The results indicated that, biometric parameters in the treatment combination, FYM (25 t/ha) +

recommended dose of fertilizer (100:50:50 NPK/ha) combined with foliar spraying of panchagavya and Manchurian mushroom extract each at 3% and humic acid (0.3%) recorded maximum plant height (39.12, 68.78 and 76.7 cm), number of branches (16.2, 21.9 and 26) and plant spread (22.46, 33.76 and 55.82 cm^2) at 30th, 60th and 90th day after transplanting, respectively. The same treatment combination also recorded highest fresh shoot weight (9.05, 22.3 and 81.15 g/plant), dry shoot weight (5.35, 13.45 and 49.1 g/plant) and fresh herbage yield (0.58, 1.6 and 5.48 t/ha) at 30th, 60thand 90th day after transplanting, respectively. The content of alkaloids *viz*., phyllanthin and hypophyllanthin were also higher in the above treatment combination (0.78 and 0.29%, respectively).

P119

Impact of plant hormones on yield and alkaloid content of kalmegh (*Andrographis paniculata* Nees)

Sowmya Kumari*, K Umesha, Shivakumar[1], U S Sachin[1]

College of Horticulture, GKVK, Bengaluru-560065, Karnataka
[1]College of Horticulture, Mudigere-577132, Karnataka
*sowmya.yashodhas@gmail.com

A field experiment was undertaken to study the impact of plant hormones *viz*., NAA (@40, 50 and 60 ppm), GA_3 (@25, 50 and 100 ppm) and paclobutrazol (@100, 150 and 200 ppm) on yield and andrographolide content in kalmegh (*Andrographis paniculata* Nees.) at College of Horticulture, UHS Campus, GKVK, Bengaluru during 2013-14. Paclobutrazol at 100 ppm registered maximum fresh and dry weight of leaves as well as stem and were significantly influenced by hormonal treatments. Application of NAA at 50 ppm increased the cumulative dry herb yield, drying percentage and total andrographolide yield (3662 kg/ ha, 54.5% and 58.89 kg/ha, respectively).

P120

Influence of organic manures and spacing on herbage yield in Tulsi (*Ocimum sanctum* L.)

S Suganthi* & V Swaminathan[1]

[1]Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003 Tamil Nadu
[2]Department of Horticulture,
Agricultural College & Research Institute, TNAU, Madurai-625104, Tamil Nadu
*sukumarsuganthi14@gmail.com

Ocimum sanctum L., commonly known as Tulsi or Holy Basil, belongs to the family *Lamiaceae*. Very few studies have been carried out in the development of agro-techniques for its commercial cultivation and appropriate use of manures is considered to be very important for crop quality. Based on the results of the present study it is inferred that, application of vermicompost @ 5 t ha^{-1} under wider spacing of 50

x 30 cm was the best management practice for realizing higher productivity and can be recommended for effective and economic management of Tulsi.

P121

Studies on the effect of chemical spray on pod set, pod retention and pod yield of tamarind (*Tamarindus indica* L.) cv.PKM 1

M S Marichamy*, V Ponnuswami, G Sathish& SSaraswathy

Department of Horticulture,
Pandit Jawaharlal Nehru College of Agriculture, Karaikal-609603, Tamil Nadu
*marichamy.ms@gmail.com

A field experiment was conducted to evaluate the effectiveness of foliar spray of different chemicals such as calcium chloride @1 and 2%, calcium nitrate @1%, potassium sulphate @1%, potassium chloride @1%, borax @1% and bioinoculants (FP7),*Pseudomonas fluorescens* (0.2%), along with chitin (0.5%) on pod set, pod retention and pod yield of tamarind (*Tamarindusindica*) cv. PKM 1 during 2009-2010 at Chittaiyankottai, Sempatti, Dindigul. The results revealed that, foliar application of potassium sulphate @1% exhibited higher pod set (33.33 and 35.16%), pod retention (55.4 and 58.55%), pod length and width (15.46 cm 15.66 cm and 2.77cm and 2.88 cm). Application of potassium sulphate @1% recorded the highest pod yield (17.93 kg tree^{-1} and 19.68 kg tree^{-1}), individual pod weight (24.80 g and 26.73 g), seed weight per pod (6.58 g and 7.09 g), shell weight per pod (5.51 g and 5.94 g) and fibre weight per pod (1.06 g and 1.15 g).

P122

Standardization of rootstocks for resistance to *Phytophthora* wilt in betelvine (*Piper betle* L.)

M Bharathi Raja*, S Parthiban, M Ananthan, S Mohan & R Sundaram

Horticultural College & Research Institute,TNAU, Periyakulam-625604, Tamil Nadu

An experiment on standardization of rootstocks forresistance to *Phytophthora* wilt in betelvine(*Piper betle* L.)was carried out during August 2010 to June 2012 at Horticultural College and Research Institute, Periyakulam. Screening of six wild species of *Piperviz*., *P. colubrinum, P. hymenophyllum, P. longum, P. nigrum, P. attenuatum* and *P. betle* for both foot rot and parasitic nematode was taken up, besides assessing their rooting ability and grafting success. The results revealed that, the number and length of sprouts per cuttings were the maximum in *P. colubrinum* compared to other *Piper* species. Among the wild species, *P. colubrinum* recorded the maximum rooting (82.24%). The highest grafting success among the wild species was obtained with, *P. colubrinum* (59.39%) and the scion material Patchaikodi (58.99%). The leaf length of two scions *viz*., Patchaikodi and Vellaikodi grafted on *P. colubrinum* recorded the highest leaf length (6.02 cm). Screening studies revealed that, *P. colubrinum* and *P. hymenophyllum* were immune, while the scion materials were highly susceptible. The grafts of these two species as rootstock also exhibited immune reaction. *P. colubrinum* was found to be highly

resistant against *Meloidogyne incognita*, whereas the scion materials were found susceptible. The grafts of these wild species as rootstock did not exhibit wilting symptoms and thus categorized as highly resistant. It is concluded that, the rootstocks with multiple resistance *viz*., *P. colubrinum* and *P. hymenophyllum* can be commercially exploited for faster rate of multiplication in the nursery for the production of rooted cuttings of betelvine.

P123

Management of leaf blight disease in *Gloriosa superba*

B Meena* & K Rajamani

Department of Medicinal & Aromatic Crops,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*meepath@rediffmail.com

Gloriosa superba L. (*Liliaceae*) is a tuberous climbing plant with brilliant wavy-edged yellow and red petalled flowers commercially grown for colchicine. Leaf blight caused by *Alternaria alternata* is an important disease of *G. superba* and field experiments were conducted at Vellipalayam, Coimbatore, Tamil Nadu during 2013-2014 for the management of leaf blight disease. The tubers were dipped in biocontrol agent *viz*., *Bacillus subtilis* at the rate of 2 g per litre or fungicide, carbendazim @0.1% for 20 minutes before planting. Foliar application of *B. subtilis* @2 g per litre or carbendazim @0.1% was done at 60 days after planting. The leaf blight intensity was assessed on 90 days after planting using 0-9 disease rating scale. The results revealed that, dipping the tubers in *B. subtilis*, followed by folair spray with *B. subtilis* 60 days after planting was highly effective in managing leaf blight under field conditions. The growth and yield parameters*viz*., plant height, number of flowers per plant, number of pods per plant, number of seeds per pod and seed yield were found to be the maximum with tuber treatment, followed by folair spraying with *B. subtilis*.

P124

Soil borne diseases of glory lily and their management

D Alice & B Meena*

Department of Plant Pathology,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*meepath@rediffmail.com

Glory lily (*Gloriosa superba* L.) is an important medicinal plant grown commercially for the chemical compound, colchicine. Root rot incited by *Macrophominaphaseolina* causes economic losses in *G. superba* to a greater extent. Field eperiments were conducted at Vellipalayam, Coimbatore, Tamil Nadu for the management of root rot disease using amendments, botanicals, biocontrol agents and fungicides. Soil application of *Trichodermaviride* was done at the rate of 2.5 kg/ha. Soil amendment with Iluppai cake was done at the rate of 150 kg/ha. Other treatments were, foliar spray with notchi leaf extract (10%), *Pseudomonasfluorescens* (0.2%), Iluppai oil (3%), zinc sulphate (0.5%) and soil drenching with carbendazim (0.1%). Basal application of zinc sulphate @25 kg/ha was common for all the treatments except control.The result revealed that, soil application of *T. viride* was most effective in managing root rot disease with the lowest disease incidence (12.2%) and maximum seed yield. It was found to be on par with foliar sprays of *P.fluorescens* (12.5%) and zinc sulpahte (12.8%) whereas, the maximum disease incidence was noticed with notchi leaf extract (25.3%) and control (30.4%).

P125

Effect of organic manures and bio stimulants on growth, yield and quality of curry leaf (*Murraya koenigii* Spreng) cv. Senkambu

G Karthik Kannan, SSubramanian*, PParamaguru, SMohandass & PSubramanian

Horticultural Research Station, TNAU, Thadiyankudisai-624212, Tamil Nadu
*hrstkd@tnau.ac.in

Curry leaf (*Murraya koenigii* Spreng.) is a perennial nutritious herbal spice grown for its aromatic leaves. Application of organic manures and bio-stimulants play an important role in curry leaf production. Keeping this in view, an experiment with foliar spray of *Pseudomonas fluorescens* (2%), panchagavya (3%), vermiwash (3%) and humic acid (0.5%) was undertaken during *rabi* and summer seasons along with organic manures *viz.,* poultry manure (12 t/ha), groundnut cake (2 t/ha) and composted coir dust (12.5 t/ha). At the time of harvest (90 DAP), the plants applied with poultry manure 12 t ha^{-1} + foliar spray of panchagavya (3%) recorded higher values for the growth parameters *viz.,* plant height, number of matured shoots, internodal length between two compound leaves, length and weight of matured shoots, number of compound leaves per mature shoot and number of leaflets per compound leaf; physiological parameters *viz*., leaf area, specific leaf area, chlorophyll a, b, total chlorophyll content and above ground biomass; leaf nutrient content such as nitrogen, phosphorus, potassium, calcium, magnesium, iron and fresh leaf yield as well as quality characters *viz*., essential oil, oleoresin and leaf to powder percentage, shelf life and B:C ratio.

P126

Effect of different levels of fly ash and vermicompost on growth and yield of lemongrass

P Srinivas*, S S Vijaya Padma, K P Sastry, K B Suneetha Devi & G Sharon Rose

College of Horticulture, Rajendranagar-500030, Hyderabad, Telangana
*seenu.puli1988@gmail.com

Lemongrass is a tropical multi-cut perennial grass which yields aromatic oil containing 70-90% citral. Its oil is used widely in perfumery industry, cosmetics, synthesis of vitamin A, flavouring herbal teas and other non-alcoholic beverages, confectionaries, scenting of soaps, detergents and insect repellent preparations. Organic farming is gaining momentum especially in the cultivation of medicinal and aromatic plants owing to reputed improvements in the quality of the produce under organic systems of farming as well as the price premiums for certified produce. Hence, with a view to study the effect of

organic manures on growth and herb yield, an investigation was undertaken with different levels of fly ash and vermicompost in 2014-2015 at CIMAP, Boduppal, Hyderabad. The experiment was carried out in randomized block design with three replications. There were thirteen treatments with different combinations of fly ash and vermicompost. The results enunciated that, among the treatments, T_7 (FA 6 t/ha + VC 4 t/ha) recorded significantly higher plant height (154.6 cm), number of tillers (42), number of leaves (142), leaf area (207.4 cm^2), dry matter (31.5%) and herb yield (17.8 t/ha). The results from the experiment demonstrated that, among the different treatments, the treatment T_7 with fly ash 6 t/ha and vermicompost 4 t/ha as the best treatments for obtaining higher plant growth, herb yield and oil content of lemongrass.

P127

Effect of fly ash and vermicompost on plant growth and herb yield in palmarosa

G Sharon Rose*, K Venkatalaxmi, K P Sastry & P Srinivas

College of Horticulture, SKL TSHU, Rajendranagar-500030, Hyderabad, Telangana
*sharonlizziejohn@gmail.com

Palmarosa (*Cymbopogon martini* Stapf. var. *motia*), an aromatic perennial grass, is a native of sub-tropical India and well known for its essential oil. Organic farming is gaining momentum especially in the cultivation of medicinal and aromatic plants to obtain quality produce. Hence, the present investigation was carried out with different levels of fly ash (FA) and vermicompost (VC) at Central Institute of Medicinal and Aromatic Plants (CIMAP), Boduppal, Hyderabad during 2014. The experiment was carried out with thirteen treatments in randomized block design with three replications. The data revealed that, the treatment T_7 (FA 6 t/ha + VC 4t /ha) recorded significantly higher plant height (151.62 cm), number of tillers (78), number of leaves (491), leaf area (33.98 cm^2), dry matter (50.95%) and herb yield (11.29 t/ha) and was on par with other treatments for all the parameters.

Session III

Mechanization, Post Harvest Management & Quality Standards

Lead Lectures

L10

Harmonization of quality standards in spices

M R Sudharshan

Former Director (Research), Spices Board, Kochi-682025, Kerala
sudharshan.mr@nic.in

The history of spices is associated with the history of commerce and trade. It is the spice trade that has led to the exploration of continents and landscapes, built up platforms for cultural exchange between civilizations and has eventually laid the foundation stone for the evolution of the entire world to the present stage – 'a global village' by building up cross border ties across nations.

Economic integration and globalization of food trade has resulted in the international food trade growing from 22 billion dollars in 1963, to more than 1.3 trillion dollars today. Spices form a significant part of the food, adding value to it by way of flavour and aroma. The global market for spices is rapidly expanding and the market dynamics are frequently changing based on food safety and quality standards.

The international production of spices and herbs has increased from 6.5 million MT in 2004 to more than 10 million MT in 2011 and the world trade has now reached a level of 4.5 million MT and the demand is continuously on the rise. The spices are mainly produced in Asia, Africa, Near East and Latin American countries. It is noted that, spices and aromatic herbs are also produced in some countries of the European Union and United States.

Spices Production: World Trend

Production (MT)	1965	1995	2000	2005	World Share (%)
World	1,731,758	4,306,948	6,005,055	6,578,488	100%
Developed countries	183,970	175,566	184,233	236,810	3.6%
Developing countries	1,547,788	4,131,382	5,820,822	6,341,678	96.4%

Source: Calculations based on FAOSTAT

The world import of spices has been going up year after year. The global export of spices (volume) and aromatic herbs have shown the following trend:

Product Group (MT)	2003	2007	2010
Spices	1,543,067	8,921,762	13,326,529
Aromatic herbs	2,904,792	3,507,775	3,645,152

Source: Calculations based on ITC trade map

India is the largest producer, consumer and exporter of spices in the world. The estimated world trade in spices is more than 1.42 million tonnes valued at US $ 4750 million out of which India has a significant share of 48% in quantity and 43% in value (2011-12). India exports around 180 spices/spice products to over 150 countries. Export of spices from India has reached 893,920 MT valued at Rs. 14,899 crores during 2014-15. The major spices exported from India are black pepper, chilli, turmeric, seed spices, mint products and spice oils and oleoresins.

The major markets for Indian spices and spices products are USA, Malaysia, China, Germany, Bangladesh, UK, UAE, Sri Lanka, Singapore, Netherlands, Saudi Arabia, Indonesia, Nepal and Brazil. Estimated zone wise export of spices from India in value terms in 2013-14 was, East Asia (45%), American Zone (19%), European Union (14%), West Asia (10%), Latin America (4%) and others (8%).

Food safety

Food safety is a concept that food will not cause harm to the consumer when it is prepared and/ or eaten according to its intended use. The need for food safety arises because

- New products are coming to the market at a fast pace.
- New processing methods and equipments are emerging.
- World market and consumption patterns are changing.
- Novel pathogens are emerging.

WTO has made it mandatory for all member states to follow International Food Standards (IFS) and guidelines in the sphere of foreign trade. Importance of these guidelines is the compliance with HACCP.

Food quality

"Quality" comprises both subjective and objective characteristics and can be termed as "fitness for consumption". The term quality has been defined as the totality of features relevant to the ability of a product to fullfill its requirements determined by the producer, manufacturer, or consumer. Correct handling, preparation and storage methods set the standard quality of the product. Food safety is generally and implicit part of food quality. Food safety is integrated within food quality assurance and quality control programmes. Food quality control is closely tied to the manufacturing processes ensuring raw materials meet quality specifications.

Food safety concerns

In 1993, a single food borne Salmonellosis outbreak in Germany caused an estimated 1000 illnesses. Trace back investigations determined the contaminated ingredient was a spice (paprika) in the potato chip snack-food seasoning. The outbreak demonstrated that, minor ingredients such as spices can cause large-scale food-borne illness outbreaks, even when the food is low moisture and the level of contamination is small.

The presence and level of food borne pathogens in dried spices is impacted by production and handling. The supply chain for black pepper and other spices is typically very complicated, often beginning with small-scale farms which may use outdoor drying, where additional dust, insects, animal waste and water may come in contact with the spice, if proper precautions are not taken (American Spice Trade Association-ASTA 2011). Once dried, spices generally pass through multiple storage, processing, packing and repacking events that can span years.

Because most spices are grown in developing countries where sanitation and food handling practices may not be adequate, the spice industry must develop processes that effectively and reliably eliminate pathogens from spices. Historically, *Salmonella* is the most common bacterial pathogen associated with product recalls and outbreaks in spices. In addition, presence of contaminants, pesticide residues, mycotoxins also pose threat to human health.

Diversity in food safety and quality standards

The member countries of WTO gives opportunity to set quality and safety standards through SPS. Such countries can set their own national standards to provide Appropriate Level Of Protection (ALOP) to their citizen. Countries like USA, EU, Japan, *etc.* have used these provisions setting their own country standards. The regulatory bodies of such countries have their own stringent food safety requirements on pesticides (maximum residue limits – MRLs) and maximum levels on mycotoxins, heavy metals and microbial contaminants.

The Food Safety Modernization Act (FSMA) of USA:isan amendment to the Federal Food, Drug and Cosmetic Act, signed into law on January 4, 2011 (FSMA, 2011). The FSMA aims to ensure the U.S food supply is safe by shifting emphasis from incident response to prevention of contamination. FSMA requires food safety plans for the entire food safety.
The main themes of the legislation are:

- Prevention
- Inspections, compliance and response
- Import safety
- Enhanced partnerships.

It brings more import safety mandates and preventive controls like HACCP, food tracking and tracing, record keeping (traceability), foreign supplier verification programmes, voluntary qualified importer programmes and certification of high-risk food imports (perishable foods like seafood). Accreditation of third-party auditors, international capacity building on food safety management system is the pro-active programmes to prevent the food hazards at the supply chain management. FSMA language relating to hazard analysis is consistent with the HACCP approach outlined in ASTA's HACCP Guide for Spices and Seasonings (ASTA, 2006).

European Union (EU):The EU Regulations on food and feed for food producing animals are equally applicable to the EU member countries as well as third countries exporting food and feed to the EU countries. Food and Veterinary Office (FVO) is the responsible body for the issues concerning on animal health whereas, European Food Safety Authority (EFSA) deals with issues on remaining areas of food safety and quality.

The Rapid Alert System for Food and Feed (RASFF):The system, created in 1979, enables information to be shared efficiently between its member countries and their food safety authorities. It ensures the cross-border flow of information to swiftly react with risks to public health that are detected in the food supply chain. Through RASFF, vital information on food safety can be exchanged and such products can be recalled from the market.

The Food Safety Authority of Australia and New Zealand (FSANZ), the Canadian Food Inspection Agency (CFIA), The Food Safety Basic Law of Japan (under Ministry of Health, Labour and Welfare) are some of the regulatory agencies responsible to facilitate trade and establish food safety and quality standards for their community and the food traded into their territory by other countries.

Food Safety and Standards- India:With respect to national laws, regulating the safety and quality of foods in post-independent India, the government enacted a central legislation called Prevention of Food Adulteration Act, 1954 along with several product specific orders. Enforcement of PFA act was mainly done by States/UT governments, wherein Central Government primarily playing an advisory role with statutory standardization.

AGMARK and Bureau of Indian Standards (BIS) provide basic assurance about quality of agriculture produce and products/service, respectively. Primarily, BIS has two fold activities; first, formation of

Indian standards and secondly, to implement the standards through voluntary and third party certification. In addition to this, BIS creates consumer awareness and maintain close liaison with International Standard bodies like International Organization for Standardization (ISO), International Electro Technical Commission (IEC) and World Standard Service Network (WSSN).The Export Inspection Council (EIC) is responsible for quality control and inspection of large number of export commodities, through compulsory pre-shipment inspection. EIC administers this through its regional agencies and network of officers located around major processing centres and port of shipments. Commodity boards such as Spices Board, Tea Board, Coffee Board, National Diary Development Board and organizations like APEDA and MPEDA also provides safety measures for export oriented food products to avoid rejections of consignments at Importing country, for product not conforming to specific quality/food safety standards, pertaining to their scope of activity.

With objective to establish single reference integrated law for foods and to overcome the implementation complexities of multiple acts regime, Government of India has enacted *Food Safety and Standards Act (FSSA).* Under FSSA 2006, Food Safety and Standards Authority of India (FSSAI) -an autonomous statutory body with Ministry of Health and Family Welfare is established to formulate and implement the act. With effect from 5thAugust 2011, Food Safety and Standards (Food Products Standard and Food Additives) Regulation, 2011 has been implemented.

The objectives of FSSA is to lay down science based standards for foods and to regulate manufacture, sale and import to ensure safe and wholesome foods. The act lays emphasis on risk assessment, risk management and risk communication including those pertaining to use of food additives, processing aids or hazards to achieve Appropriate Level of Protection (ALOP) to Human Health. FSSA emphasizes labelling, traceability and recall procedures. FSSA incorporates Food Safety Management System, consisting of GMP, GHP and/or HACCP.

Harmonization of standards

United Nation General Assembly in 1985, have evolved guideline for consumer protection, which states 'when formulating national policies and plans with regards to food, Government shall take in to account the needs of all consumer's food safety as far as possible, adopt the standards from Codex Alimentarius. In 1992, FAO/WHO recognized that access to nutritionally adequate and food safety is right of every individual.In 1995, the Agreement on the Application of Sanitary and Phytosanitary (SPS) measures and the Agreement on Technical Barriers to Trade (TBT) by The World Trade Organization (WTO) are the most significant for international food trade.

The world order for food trade places greater obligation on part of both importing and exporting countries to ensure safety of food. The WTO agreement covers goods, services and intellectual property, which include individual country's commitment to lower custom tariffs and other trade barriers to open service markets. Agreement on SPS set sound basic rules for food safety and standards for plant (International Plant Protection Convention- IPPC), for animal health (World Organization for Animal Health - OIE-*Office International des Epizooties)* and for human health (Codex Alimentarius Commission - CAC). All countries are required to maintain measures that food is safe for consumers and to prevent the spread of diseases among animals and plants. WTO recognizes Codex Standards as benchmark for food safety because they are based on science and risk assessment.

These SPS measures may include inspection of product, their specific treatment, permitted use of specific additives and setting of allowable maximum level of pesticide residues. Basic aim of SPS agreement is to maintain the sovereign right of any government to provide the level of health protection, it deems appropriate, but to ensure that these sovereign rights are not misused for protectionist purposes and do not result in unnecessary barriers to International trade. Governments are sometimes pressured to go beyond what is needed for health protection and to use SPS restrictions to shield domestic producers from economic competition. In terms of food, labelling requirements, nutrition claims and packaging regulations are generally not considered to be sanitary or phytosanitary measures and hence are normally subject to TBT agreement. The TBT agreement refers to technical regulations and conformity assessment procedures and applies to all commodities, not just for food.

Different international agencies like, International Organization for Standardization (ISO), International Dairy Federation (IDF) World Organization for Animal Health (OIE), International Plant Protection Convention (IPPC) and International Trade centre (ITC) are very effectively involved in formulating standards for different food products.

Majority of the organisations engaged in development and contribution towards food safety and quality standards are either in the Government set up or Government sponsored or influenced by the food manufacturers and regulators. There are very few non- government organisations engaged in food safety and quality. However, considerable number of NGO's are engaged in Codex alimentarious process. The main focus of the NGO's is towards protection of the consumer rights rather than contribution towards development of food quality and safety standards. Scientific organisations like Association of Official analytical Chemists (AOAC), American Society for Testing and Materials (ASTM), International Life Science Institute (ILSI) are some of the NGOs working in their respective field, have an objective to develop and harmonize quality and safety standards for food.

The Codex Alimentarius Commission is an intergovernmental body of the United Nations, established by FAO and WHO in 1963. It develops harmonized international food standards, guidelines and codes of practice to protect the health of the cosumers and ensure fair practices in the food trade. The Commission also promotes coordination of all food standards work undertaken by international governmental and non-governmental organizations. The Codex Alimentarius system presents an unique opportunity for all countries to join the international community in formulating and harmonizing food standards and ensuring their global implementation. It also allows them a role in the development of codes governing hygienic processing, practices and recommendations relating to compliance with those standards.

By far the largest number of specific standards in the Codex Alimentarius is the group called "commodity standards". The major commodities included in the codex are:

- Cereals, pulses and legumes
- Fats and oils
- Fish and fishery products
- Fresh fruits and vegetables
- Processed fruits and vegetables
- Milk and milk products
- Sugars
- Spices and culinary nerbs

Commodity standards tend to follow a fixed format set out in the Procedural Manual of the Codex Alimentarius Commission. The format consists of the following categories of information:

- *Scope* includes the name of the food to which the standard applies and, in most cases, the purpose for which thecommodity will be used.
- *Description* includes a definition of the product or products covered with an indication, where appropriate, of the raw materials from which they are derived.

- •*Essential composition* includes information on the composition and identity characteristics of the commodity, as well as any compulsory and optional ingredients.
- *Food additives* contain the names of the additives and the maximum amount permitted to be added to the food. Food additives must be cleared by FAO and WHO for their safety and the use of food additives must be consistent with the Codex General Standard for Food Additives.
- *Contaminants* contains limits for contaminants that may occur in the product(s) covered by the standard. These limits are based on the scientific advice of FAO and WHO and must be consistent with the Codex General Standard for Contaminants and Toxins in foods. Where appropriate, reference is also made to the Codex Maximum Limits for pesticide residues and for residues of veterinary drugs in foods.
- *Hygiene* makes reference to relevant codex codes of hygienic practice for the commodity concerned. In almost all cases it is required that the product shall be free from pathogenic microorganisms or any toxins or other poisonous or deleterious substances in amounts that represent a hazard to health.
- *Weights and measures* contains provisions such as fill of the container and the drained weight of the commodity.
- *Labelling* includes provisions on the name of the food and any special requirements to ensure that the consumer is not deceived or misled about the nature of the food. These provisions must be consistent with the Codex General Standard for the Labelling of Prepackaged Foods. Requirements for the listing of ingredients and date-marking are specified.
- *Methods of analysis and sampling* contains a list of the test methods needed to ensure that the commodity conforms to the requirements of the standard. References are made to internationally recognized test methods that meet the Commission's criteria for accuracy, precision, *etc.* applying Codex Standards.

The harmonization of food standards is generally viewed as contributing to the protection of consumer health and to the fullest possible facilitation of international trade. For this reason, the Uruguay Round Agreements on the Application of Sanitary and Phytosanitary Measures and on Technical Barriers to Trade (SPS and TBT Agreements) both encourage the international harmonization of food standards. While the growing world interest in all Codex activities clearly indicates global acceptance of the Codex philosophy – embracing harmonization, consumer protection and facilitation of international trade – in practice it is difficult for many countries to accept Codex standards in the statutory sense.

Differing legal formats and administrative systems, varying political systems and sometimes the influence of national attitudes and concepts of sovereign rights impede the progress of harmonization and deter the acceptance of Codex standards. Despite these difficulties, however, the process of harmonization is gaining impetus by virtue of the strong international desire to facilitate trade and the desire of consumers around the world to have access to safe and nutritious foods. An increasing number of countries are aligning their national food standards, or parts of them (especially those relating to safety), with those of the Codex Alimentarius. This is particularly so in the case of additives, contaminants and residues, *i.e.* "the invisibles".

Conclusion

It is noteworthy that the SPS and TBT Agreements both acknowledge the importance of harmonizing standards internationally so as to minimize or eliminate the risk of sanitary, phytosanitary and other technical standards becoming barriers to trade. In its pursuance of harmonization, with regard to food safety, the SPS agreement has identified and chosen the standards, guidelines and recommendations established by the Codex Alimentarius Commission for food additives, veterinary drug and pesticide residues, contaminants, methods of analysis and sampling and codes and guidelines of hygienic practice. This means that Codex standards are considered scientifically justified and are accepted as the benchmarks against which national measures and regulations are evaluated.

Considerable interest in the commission's activities has been stimulated by the specific recognition of Codex standards, guidelines and recommendations within the SPS Agreement, as well as the importance assumed by Codex standards in the Technical Regulations and Standards provisions contained in Article 2 of the TBT agreement, even though the Codex standards are only voluntary standards. Consequently, attendance at Codex meetings, especially by developing countries, has markedly increased. This is a welcome development, particularly as both Agreements direct members, within the limits of their resources, "to play a full part" in the work of international standards organizations and their subsidiaries.

The adoption of Codex standards as scientifically justified norms for the purpose of the SPS and TBT agreements is of immense significance. The standards have become an integral part of the legal framework within which international trade is being facilitated through harmonization. Already, they have been used as the benchmark in international trade disputes and it is expected that they will be used increasingly in this regard.

In spite of the fact that the trade and consumption of spices, culinary herbs and their formulations has increased many fold and new uses are being identified everywhere in the world, there are no internationally harmonized standards for these products.

In Codex Alimentarius Commission, there was no separate committee for standard setting work on spices and culinary herbs. Spices Board, with the support of National Codex Contact Point, FSSAI, Government of India with a view to develop harmonized international standards under the Codex, took initiative to propose a separate committee for spices and culinary herbs and gathered support from many spices producing member countries. This resulted in the establishment of Codex Committee on Spices and Culinary Herbs (CCSCH) under Codex Alimetarius Commission, during 2014.

The terms of reference of CCSCH are (a) to elaborate worldwide standards for spices and culinary herbs in their dried and dehydrated state in whole, ground and cracked or crushed form. (b) to consult, as necessary, with other international organizations in the standards development process to avoid duplication.

India being the largest producer, exporter and consumer of spices in the world volunteered to host CCSCH and the committee meets once in 18 months. The committee has met twice so far and has finalized work management modalities, mechanisms for prioritization of work. It has taken up work of elaboration of standards for black, white and green pepper, cumin, oregano and thyme. Ten more spices are kept in the priority list for elaboration of standards.

The harmonization of standards for spices, culinary herbs and their formulations would bring the following benefits:

- Comprehensive work on internationally harmonized food standards through inter-governmental international organization - Codex
- Promote consumer protection through improvement in the quality of food products
- Ensure transparency in international trade in these products
- Exchange of information across trading partners is standardized
- Supports fair practices in trade and encourage trade-supporting equivalence determination
- Provide confidence to small producers of these products and facilitate market access, particularly, for several developing countries in all the regions
- Enhance technical ability to meet standards and promote capacity building

- Standardization of these products would bring about uniformity in certification and enable cost efficiency
- Improve stakeholder involvement in the development of national standards and certification procedures
- Support better production practices and eliminate trade distortions much to the benefit of developing countries
- Provide safe and quality products to the consumers

Harmonization of quality standards in spices ensures fair practices in spices trade and protects the health of consumer world over.

L11

Innovations on spice processing - An overview

M Madhava Naidu

Department of Spices & Flavour Science,
CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
mmnaidu@cftri.res.in

Spices are a group of secretive food adjuncts that have been in use for centuries to enhance the sensory quality of foods, the quantity and variety consumed in tropical countries is particularly extensive. The word 'spice' is synonymous with anything that creates a piquant effect. Although spices have never been considered to contribute anything to human nutrition, this group of food adjuncts has been used in human diets for centuries as flavour modifiers to make food more palatable.Since ancient times, India has been the house of many important spices like turmeric, pepper, ginger, garlic, cardamom and chilli. India, with its favourable climatic conditions for growing spices, is the largest producer and consumer of spices. During 2015-16, India targeted to export an estimated 12 lakh tonnes of spices and spice products, which are worth more than US $ 2500 millions. Dehydrated spices with their bioactive constituents have been shown to have good consumer acceptance as well as shelf life and could serve as a valuable food additive to enhance human nutrition. With the increasing interest in the beneficial role of spice nutraceuticals in health, in-depth study of the bioactive constitutents of spices assumes significant prominence. In this direction, Department of Spice & Flavour Science, CSIR-CFTRI conducts basic research on chemistry and development of new spice –based processes, products and spice processing machinery. Therefore the purpose of this presentation is to provide a comprehensive review on the recent research/technologies on spice processing, including value addition and its nutraceutical applications.

Spices are aromatic and or pungent plant material used to flavour food. The word 'spice' is synonymous with anything that creates a piquant effect. Since ancient times, India has been the house of many important spices like pepper, cardamom and ginger. India, with its favourable climatic and soil conditions for growing spices, is the largest producer, consumer and exporter of spices. During 2014-15, India targeted to export an estimated 12 lakh tonnes of spices and spice products, which are worth around US $ 2500 million. Though India is a major producer of spices, not much attention has been paid to the improvement in the quality of whole dry spices. The importing countries are very particular about standards relating to safety and hygienic quality in the spices including the absence of foreign material. Of late, in international trade, much emphasis is being laid to microbial load, pesticide residues and heavy metal contamination.

Processing of spices

Harvesting

Spices are usually harvested when they are fully mature on the plant. For some spices harvesting is done at different stages of maturity to meet the specific needs of the end product. In the case of pepper, fully mature spikes are harvested for making black pepper or white pepper, whereas immature pepper (7-8 months old) is harvested for use in canned pepper, pepper in brine and dehydrated green pepper. In the case of chillies, in India, fully mature fruits are harvested manually. They are heaped for a day or two for proper development of the red colour and then they are sundried. In Japan harvesting is done mechanically, either by cutting the whole plant or branches. Chillies are destalked before drying. This helps in faster drying and also there will be no spillage of seeds. In ginger, fully mature green rhizomes are harvested for use as fresh spice or converted into dry ginger. This dry ginger is used for making powder and also in oil and oleoresin extraction. On the other hand, tender and less fibrous ginger is preferred for making products like candy, preserve, pickles, *etc*. In the cases of cardamom and turmeric fully mature spices are harvested and suitably processed.

Drying

After harvesting drying is the most important step.

i. Sun drying is very commonly practiced. Spices are dried on mats or on mud yards. Here contamination from soil and other extraneous sources can take place.
ii. An improvement over this is drying the spices on raised cement platforms. Here contamination from soil is eliminated.
iii. As a further improvement over this, the cement yards are covered with nylon nets which help in preventing contamination from birds excretes and other extraneous matter. Mechanical drying for some spices is employed which helps in getting safe and hygienic product, but it will be costlier than sun drying.
iv. Newer methods of drying include microwave heating and infrared heating especially in case of herbs were most of its bioactive components needs to be retained during processing has been developed. Electromagnetic radiation finds applications ranging from blanching, drying, backing and roasting of herbs. As this is a dry heating processes much valuable nutrients can be conserved which may be lost during blanching.

Quality of spices

Quality is a complex term to define and it would vary with the consumers needs. Quality can be deemed to comprise of physical, chemical, microbiological and sensory attributes. Cleanliness specifications as prescribed by the ASTA for various spices and herbs are given in Table 1.Besides this, lot of emphasisis laid on the microbial quality of spices. Contamination of spices by heavy metals *viz*. lead, zinc, copper, mercury etc. are also likely to pose problems in external and internal trade. Similarly, residual pesticides on the spices pose health hazards for the consumers.

Microbiological quality of spices

Spices are known to harbour various types of microorganisms, which are either of spoilage significance or public health significance. Spices at the time of harvest contain moisture range to 80-90 per cent, which must be brought down to a safe moisture level of 8-12 per cent from the microbiological point of view. It is possible that spices get contaminated at any step during processing. The primary processing of spices should not only ensure the retention of the valuable properties of the spice like flavour, colour and pungency but also its hygienic quality. Mould growth would occur in spices not dried properly and in a few cases the problem of aflatoxin has been noticed. According to PFA, the maximum permitted level of aflatoxin is 3 ppb. Spices meant to be used as table condiments should be free of salmonella and other microbial pathogens. Thermophyllic spore formers could cause spoilage of canned food. In dry spices major components of micro flora constitute aerobic spore formers. Black pepper is a major source of aerobic spore forming bacteria and many of them are heat resistant and hence are a dominant survival organism in inadequately heat processed products. In order to improve the microbial quality of spices, it is necessary to take adequate precaution at each stage of processing.

Table 1. Cleanliness specification for spices, seeds and herbs

Name of spice, seed of herb	Whole insect, dead by count	Excreta mammalian by mg/Lb	Excreta other by mg/Lb	Mold By Wt	Insect defiled/ infers-ted % by wt	Extraneous/ foreign matter % by wt
Allspice	2	5	5.0	2.0	1.00	0.50
Anise	4	3	5.0	1.00	1.00	1.00
Sweet basil	2	1	2.0	1.00	1.00	0.50
Caraway	4	3	10.0	1.00	1.00	0.50
Cardamom	4	3	1.0	1.00	1.00	0.50
Cassia	2	1	1.0	5.00	2.50	.50
Cinnamon	2	1	2.0	1.00	1.00	0.50
Celery seed	4	3	3.0	1.00	1.00	0.50
Chillies	4	1	8.0	3.00	2.50	0.50
Cloves	4	5	8.0	1.00	1.00	1.00
Coriander	4	3	10.0	1.00	1.00	0.50
Cumin seed	4	3	5.0	1.00	1.00	0.50
Dill seed	4	3	2.0	1.00	1.00	0.50
Fennel seed	-	-	-	1.00	1.00	0.50
Ginger	4	3	3.0	-	-	1.00
Laurel leaves	2	1	10.0	2.00	2.50	0.50
Mace	4	3	1.0	2.00	1.00	0.50
Marjoram	3	1	10.0	1.00	1.00	1.00
Nutmeg (broken)	4	5	1.0	-	-	0.50
Nutmeg(whole)	4	0	0.0	-	-	0.00
Oregano	3	1	10.0	1.00	1.00	1.00
Black pepper	2	1	5.0	-	-	1.00
White pepper	2	1	1.0	-	-	0.50
Poppy seed	2	3	3.0	1.00	1.00	0.50
Rosemary laves	2	1	4.0	1.00	1.00	0.50
Sage	2	1	4.0	1.00	1.00	0.50
Savory	2	1	10.0	1.0	1.00	0.50
Sesame seed	4	5	10.0	1.0	1.0	0.50
Sesame seed (hulled)	4	5	1.0	1.0	1.00	0.50
Tarragon	2	1	1.0	1.0	1.0	0.50
Thyme	4	1	5.0	1.00	1.00	0.50
Turmeric	3	5	5.0	3.00	2.50	0.50

Irradiation

Gamma irradiation has been found to be extremely reliable and effective in controlling or eliminating microbial as well as insect populations. BARC has carried our extensive research on disinfestations of whole and ground spices. It has been found that a dose of 5 kGycould bring down the number of bacteria in spices to below 10^3 to 10^4 organisms per gram, a requirement imposed by several important countries. This dose was also found to completely eliminate the fungi in spices. A dose of 10 kGyis recommended by the joint FAO/IAEA/WHO Expert committee for the treatment of spices. The US FDA has now cleared doses up to 30 kGy for disinfestations of spices, seasonings and blends of the same. Twenty eight countries have cleared the use of gamma irradiation for sterilization of various food materials. Recently, Govt of India has given clearance for the use of gamma irradiation for disinfestation of spices and spice products.

A thermal sterilization technology developed at CFTRI without the use of chemicals has been found to reduce the microbial load in pepper samples significantly. Water used in processing of spices, in operations such as soaking, washing, boiling *etc*. should be of potable quality. The pH or hardness of water is not a critical factor in operations such as soaking or cleaning. However, the quality of water assumes importance in the preparation of products like canned or bottled green pepper and also cleaning of dry spices to reduce the microbial load. Major spices of primary & secondary processing of some of the namely below pepper, ginger, turmeric, chilli and cardamom are discussed.

Pepper

Pepper is obtained from a perennial climbing vine, *Piper nigrum* (*Piperaceae*) and native to southern India. It is now cultivated in India, Indonesia, Malaysia, Sri Lanka and Brazil. In India, the plants flower during June-July and the spikes are ready for harvest by about January - February the next year. When the berries are fully mature, the spikes are cut off. The berries are then separated from the stalk either manually or mechanically. The separated berries are dried in the sun for 5-6 days to get black pepper. Finally, the pepper is cleaned to remove stems, husk and pinheads. About 40,000-50,000 tonnes of black pepper is being produced annually in India.Pepper has a characteristic spicy odour and a biting taste. The aroma is due to volatile oil and the pungency is due to an alkaloid piperine. Black pepper normally contains 10-12% moisture and 8-10% crude fibre. The piperine content is 3-6%.

White pepper

It is produced by removal of the outer skin or pericarp from the berries by using any one of the following techniques: i. Water steeping, ii. Boiling in water, iii. Chemical treatment and iv. Decortication. Red ripe berries, fully matured green pepper or black pepper can be used as the starting material. An yield of about 22 kg per 100 kg of fresh pepper is obtained. White pepper powder is used in the production of mayonnaise and salad dressings. World trade in white pepper is about 25,000 tonnes. Recently, an enzyme-assisted process has been developed at the CFTRI, Mysore for the preparation of white pepper from fresh green pepper. A patent has been filed on this process. Salient features of the process are given below.

- This is clean and hygienic process which delivers white pepper free from musty odour as compared to the traditional retting method.
- Product with creamy white colour is obtained without using objectionable bleaching agents or preservatives like sulfur dioxide.
- Under selected conditions of processing, the external energy input can minimized and the process can be made adaptable to field / farm level operations.
- As the de-skining of the green berries is thorough, the protein of admixture of the final product *i.e.*, white pepper with black dry berries, is almost eliminated.
- The green skin can be retrieved as a by-product which can be used for making value added products such as green colorant, flavourant *etc*.

Dehydrated green pepper

Traditionally the export of pepper from India is in the form of black pepper. In recent years there has been an increased preference for pepper with its natural green colour at least for certain specific uses in selected countries. Dehydrated pepper with its natural green colour satisfies this need and has been accepted well as a garnishing spice in preference to the traditional black pepper in some countries like Germany, France and Switzerland. Freshly harvested green pepper of optimum maturity is destalked and cleaned. The treated and processed pepper is dehydrated, classified and packed. Efforts are under way at various research institutions to find an alternative for sulphur di oxide, which is being objected to by buyers due to reasons of health hazards. CFTRI, Mysore patented a method for making dry green pepper using the High Temperature Short Time (HTST) method wherein the berries are exposed to controlled conditions of high temperature for a short time followed by mechanical drying to less than 8% moisture.

Canned green pepper

It is made from cleaned pepper berries packed in cans, covered with hot 2% brine containing 0.2% citric acid, exhausted at 80^0 C, sealed and processed in boiling water for 20 minutes and then cooled in cold water.

Bottled green pepper

It is made from cleaned pepper berries packed in bottles and covered with 20% brine containing 100 ppm SO_2 and 0.2% citric acid.

Pepper oil

This is obtained by steam distillation of the ground pepper. This oil is responsible for the characteristic spicy odour of pepper; the oil is made up of monoterpenes (70-80%), sesquiterpenes (20-30%) and oxygenated compounds (5%). The oil is used in food flavouring and perfumery.

Pepper oleoresin

This represents the total flavour of the spice and is obtained by solvent extraction of the ground pepper. Yield and quality of oleoresin are dependent on the type of raw material and solvent used. The oleoresin is made up of volatile oil, pungent principles, fixed oil, resins, colouring matter, *etc*. Pepper oleoresin is also made by using super critical extraction technique. Pepper oleoresin is used in meat industry and also in savoury foods like pickles, sauces, soups, gravies, chutneys and dressings.

Ginger

Ginger is the rhizome of *Zingiber officinale* roscoe (*zingiberaceae*), a perennial herbaceous plant native to southern Asia. It is cultivated in India, Africa, Jamaica, Indonesia, Australia, china and Japan. Harvesting of ginger is carried out about nine months after planting. India's ginger production for the year 2013-2014 was about 5,17,835 tons, of which 1,24,000 tons (24%) was produced in Assam (Source: Spices Board, India). Green ginger is more popular in Indian cookery than dry ginger. Fresh ginger is often sun dried as such or after partial peeling which facilitated drying. In Jamaica, it is completely peeled and dried. Bleached ginger is made by soaking fresh ginger rhizomes in 2% limewater for 6-8 hours. They are then removed and fumigated with sulphur fumes and dried. The process is repeated 2-3 times. This treatment, besides giving a white appearance, prevents attack by insects. Ginger contains on an average, 10% moisture, 8.3% protein, 2% volatile oil, 3.9% NVEE and 60% starch.

Ginger oil

This is obtained by steam distillation of the ginger powder. The characteristic pleasing aroma of ginger is due to its essential oil, which is present to the extent of 1-3% in the dry spice. The essential oil of ginger is a complex mixture of terpenoids. The oil is used as a flavouring material for various beverages, both alcoholic and non-alcoholic and perfumes.

Ginger preserve and candy

Fresh tender ginger or fibreless variety is used for this purpose. The ginger is peeled and cut into desired shape or size, cooked in 0.5% citric acid solution for one hour in a pressure cooker and then cooled. The ginger pieces are then impregnated with 30°Brix syrup. The process of syrup impregnation is carried out using higher strengths of syrup over a period of time. The preserve is then ready. Candy is made by taking out the ginger pieces from the syrup and rolling in finely ground sugar. The sugarcoated pieces are then shade dried.

Ginger paste

Ginger paste is a viscous product retaining the strong aroma and flavor of the raw material namely fresh ginger. The volatile oil content in the product is influenced by factors such as variety, raw material storage, handling and processing conditions. The product is generally creamy- white or off white in colour the product is microbiologically stable and free from pathogenic bacteria. Ginger paste is mainly used as a spice in culinary preparations for imparting a characteristic fresh ginger flavor. It is a ready to use preparation that can be used in place of fresh ginger in homes, restaurants and institutional catering. Ginger rhizome is the major raw material required. It is preferable to obtain ginger variety less fibrous in nature and rich in volatile oil content which is usually in the range of 0.2 to 0.4% in the fresh rhizomes. The rhizomes must be of good quality, free from mould growth, insect infestation and discoloration. The other raw materials required in lesser quantity are common salt and permitted acidulants such as a citric acid and acetic acid.

Turmeric

Turmeric is the dried rhizome of *Curcuma longa* L. (*Zingiberaceae*), an herbaceous plant native to tropical South East Asia. Allied minor *Curcuma* species include *Curcuma aromatica* Salisb, *Curcuma xanthorrhiza* Roxb *Curcuma zedoaria* Rosecoe, *Curcuma amada* Roxb and *Curcuma cassia* Roxb. Turmeric has a deep yellow colour and pungent aromatic flavour and finds application as a spice and a food colorant. India is the major producer of turmeric. Other producing countries are Bangladesh, Indonesia, China, Sri Lanka, Taiwan and Jamaica. In India, it is mainly cultivated in states of Andhra Pradesh, Maharashtra, Orissa, Tamil Nadu, Bihar, Kerala, Assam, West Bengal, Karnataka and Tripura. Most of the turmeric produced in India is consumed locally and only about 8% is exported. Turmeric is propagated by small portions of the rhizomes and becomes ready for harvest 7-9 months after planting. In India, planting is usually done during the period June to August and harvesting in February to April.

Harvesting and processing

The drying up of the plant including the base of the stem indicates maturity. In one practice of harvesting, the leaves and stems are cut close to the ground, the field is irrigated to facilitate digging out and the rhizomes carefully lifted and washed thoroughly to remove adhering soil. The yield of raw turmeric varies from 16.8 to 22.4 tonnes per hectare.

Preparation for the market

About 15 to 20% of the harvested rhizomes is retained by the farmer as seed material and the rest is prepared for the market by first separating into globular mother rhizomes and the longitudinal fingers. Roots hairs and poorly developed and shriveled portions are then removed. The bulbs and fingers are separately processed by curing, sun –drying and polishing.

Curing is essentially a process of cooking the raw rhizomes in water till soft (*e.g.* about 40 minutes for a 90 kg lot). Cooking gives the fingers (or bulbs) uniform colour; the starch gets gelatinized and the time of drying is considerably reduced. Cooked turmeric is spread on prepared yards and dried in the sun for 10-15 days. Dried turmeric usually has a low moisture content of about 6 per cent. It gives a metallic sound when broken. The dried turmeric (dry yield being usually 20-25 per cent) is polished by manual or mechanical rubbing of the surface. Mechanical polishing drums have been developed to handle small or large batches. By polishing, the scales, rootlets and some of the epidermal layer are removed; the rough and dull appearance changes to a smooth surface of brownish yellow colour. The surface colour can be further improved by external coating with turmeric powder. Lead chromate a poisonous chemical has been wrongly employed by some people to impart bright yellow colour to turmeric. However, its use is prohibited under law. Dried turmeric is transported to assembling markers, polished if required and stored in gunny bags in warehouses, periodical fumigation is necessary, as the hard dry turmeric is quite susceptible to insect infestation.

Grading of turmeric

Turmeric is graded for the export market under the AGMARK specification. Specifications have been prescribed under the following grade designations: A. Fingers (general) –special, good, fair; B. Fingers (Alleppey) - good , fair; C. Fingers, Rajapuri –special, good, fair; D. Bulbs –special, good, fair. In both fingers and bulbs, a grade denoting 'non specified' is provided to cover product not covered by other graded and exported only against firm agreement and orders. The biggest importers of turmeric are the Middle East countries like US; Japan, Singapore, Canada, Netherlands, UK and Australia also imports Indian turmeric. Cured and dried turmeric is marketed as bulbs and fingers and each type in polished and unpolished forms. Splits are bulbs which have been cut into halves or quarters before curing to facilitate subsequent drying. There are 16 major regional types recognized in the internal trade in India. They are related to traditional and familiar sources and nearness of market to production centers.

Composition of turmeric

Turmeric contains on an average moisture 6%, protein 6.5%, fixed oil 3.5%, volatile oil 4.5%, crude starch 50.4%, fibre 3% and curcumin 3.1%. Alleppey turmeric contains 6-8% curcumin. Standards require ground turmeric to contain not more than 7% total ash, 1.5% insoluble ash and 60% starch. The volatile oil obtained by steam distillation of ground turmeric is pale yellow to orange yellow in colour, with an odour reminiscent of the fingers. More than 50% of the oil is composed a mixture of sesquiterpene ketones, known as turmerone and about 25% of the sesquiterpene, zingiberene. Other constituents reported include d-1-phellandrene (1%), d-sabinene (0.6%), cineole (1%), borneol (0.5%), sesquiterpene alcohols (6.9%) and traces of alpha and gamma lactones. Turmeric oil has a very limited use in food flavouring and perfumery and is not commercially important.

Turmeric pigment

The most valued constituent of turmeric is its yellow pigment, curcumin. The colouring matter is extractable by solvents like methanol, ethanol and acetone and dichloroethylene but not by petroleum solvents. The water insoluble pigment is chiefly curcumin, (bis – feruloyl methane) besides, two cogeneric pigments, p-hydroxy cinnamoyl feruloyl methane and bis (p-hydroxy cinnnamoyl) methane and many minor uncharacterized pigments are also present.

Processed products

Ground turmeric

Turmeric is consumed mostly in the ground form to give foods an attractive yellow colour and characteristic spicy flavour. Turmeric powder is used worldwide for domestic culinary purpose. It is an important ingredient of curry powder and mustard paste. It is also used in the flavouring of poultry, sea foods, rice dished and sauces.

Recently, CSIR-CFTRI has developed a simple economically viable process and the process provides a newer method of turmeric processing. The process of obtaining the turmeric powder directly from the fresh turmeric rhizome has been achieved in a single step avoiding a labour intensive thermal treatment followed by drying in vast fields. This novel process of the present invention would enable the farmers to overcome labour intensive process of cooking, which involves not only labour but also enormous amount of agricultural fuel for boiling of water and drying of the cooked rhizomes for 20~25 days. This present process encourage farmers to think of mechanization of the simple process, which involve slicing followed by drying of turmeric within 8 ~12 h and reduce cost of processing with additional money in bank. Dried turmeric slices will have good keeping quality, with typical turmeric aroma and the finished hygienic turmeric powder, which is free from microbial load.

Turmeric oleoresin

Like other spice oleoresins turmeric oleoresin is made by solvent extraction of the powdered spice followed by removal of the solvent to get a viscous resinous preparation containing all the flavouring principles including the volatile oil and active ingredients. In addition, non-volatile fatty and resinous materials and waxes extractable by the solvent are also present. Curcumin constitutes about one third of a good quality oleoresin. Turmeric oleoresin is mixed with a suitable solubilizer like propylene glycol, polysorbate or fatty oil, so that the handling and use become easier. Various turmeric oleoresin based products are marketed in different grades of colour strength. Turmeric oleoresin is used largely in brine pickles and to some extent in mayonnaise and relish formulations, non-alcoholic beverages, gelatins, frozen fish sticks, potato preparations, butter, cheese and some ice creams.

Turmeric, especially its powder is liable for adulteration. Hence, many importing countries have prescribed statutory specifications for turmeric quality. The PFA rules require ground turmeric to contain not more than 13% moisture, 9% total ash, 1.5% insoluble ash and 60% starch.

Chillies

The most important contribution of America to the spices world is capsicum or chillies. The species capsicums belong to the family *Solanaceae*. Some twenty wild spices of capsicum are known to occur, most of which are South American. Five cultivated species are recognized namely 1) *Capsicum annuum* var *annuum* 2) *Capsicum frutescens* 3) *Capsicum baccatum* var *pendulum* 4) *Capsicum chinense* 5) *Capsicum pubescens*. Capsicums have spread throughout the world, Capsicum is also known as chilli, paprika and sweet red cayenne or red pepperdepending upon thetype and the way it is used. It should not be confused with black and white pepper from *piper nigrum*, Jamaican pepper, pimento or all spice. Sweet peppers, sometimes known as green pepper or bell pepper have the mildest flavour with little of pungent principle. They are forms of *Capsicum annuum* var *annuum*. They are generally used green and sometimes they are used in the fully ripe stage. The species *Capsicum annuum* and *Capsicum frutescens* provide the chillies of commerce.

Capsicum annuum

It has a large number of cultivars *Capsicum annuum* var *annuum* is the most important economically. The cultivated variety *annuum* has variability, particularly with regard to the fruits. It is a herb or subshrub. Erect and much branched, 45-100 cm tall and it is usually early maturing. It is grown as an annual crop. The fruit is an indehiscent, many seeded berry pendulous or erect and is usually borne singly at the nodes. It is extremely variable in size, shape and colour and in the degree of pungency. It is linear, conical or globose. The unripe fruit may be green, yellowish or purplish, ripening to red, orange, yellow or purplish colour. The flattened seeds are pale yellow and are 3.5 mm at their largest diameter. Some fruits like sweet pepper are lacking in pungency and the degree of pungency varies from mild to very pungent.

Capsicum frutescens

This species is sometimes called the bird chillies. It is a short term course lived perennial subshrub, 0.5-1.5 m high, living for 2-3 years and is late maturing. The fruits are usually small and narrow, 0.7-30 cm long and 0.3-1.0 cm wide but larger fruited forms do grow. They are extremely pungent. The fruits are green and yellow when mature and are usually red when ripe. Forms with globose, sub conical larger fruits are known. The pale yellow seeds are 2.5-3.5 mm at their greatest diameter.

Cultivation and processing

The chilli plant grows best in well drained heavy or red loam soils, as a rain fed or irrigated crop. Seedling are raised in nurseries and when 6-7 weeks old, transplanted to the fields. Flowering takes place when the plants are 2-3 months old. Harvesting commences after another three months when the green fruit become ripe and turn red. Several pickings are made at intervals of 5-10 days. Irrigated crop requires a longer time to grow and gives much higher yield than rained crop. The yield from rain fed fields may be 500-1000 kg per hectare.

The harvested fruits are heaped indoors for 2-3 days till all the fruits are uniformly ripened and red in colour. Then they are spread out in sun for drying which may take 8-15 days, depending upon the weather conditions. Yields of 25-30% of dry chillies are obtained, based on fresh weight. After drying the chillies are cleaned of extraneous matter. Damaged and discolored pods, *etc*. and then bagged. Fumigation is carried out in store to prevent insect infestation. The dried chilli is a brownish-red to red, conical fruit, 1-15 cm in length. It contains on an average, 10% moisture, 20% fibre, 14.5% protein and 16.5% non–volatile ether extractives. In the fruit, pericarp accounts for 48.5%, seed 44.5% and stems 7.0%.The fruits give a very small amount of volatile (0.5-0.8%) ether extract. However no essential oil containing the aromatic principle has been isolated. The pigment content of chillies is 0.2-0.5%. The principal colouring matter is carotenoid pigment capsanthin (3.5%) - others present being carotene, capsorubin, zeaxanthin, cryptoxanthin, *etc*. Colour deterioration in the fruits and powder is attributed to the oxidation of pigments which is influenced by moisture, storage temperature and light. The pungent principle in the chillies is capsaicin, present to an extent of 0.2-1%. It is an alkaloid of the molecular formula $C_{18} H_{27}No_3$ and is a substituted benzyl amine derivative.

Chilli oleoresin

Chillies and chilli powder are subject to infestation and mould attack and also discolouration and loss of flavour during storage. These difficulties are eliminated by conversion to oleoresin. Further, oleoresins offer a convenient way of standardizing the quality and strength of flavour. For oleoresin extraction, yield of non–volatile extract, colour and pungency are important factors. Solvent extracted chilli oleoresin is in demand for food flavourings.

Cardamom

Cardamoms are the dried fruits of a perennial herb, *Elettaria cardamomum* belonging to the family *Zingiberaceae*. It is one of the most important and valuable spices and is often called as the queen of spices. It is indigenous to the evergreen forests of the western gats in South India. India is one of the largest producer and exporter of cardamoms. It is grown in other tropical countries like Guatemala, Tanzania and Sri Lanka. In India, it is mainly cultivated in Kerala, Karnataka and Tamil Nadu.

Cardamom of commerce obtained from the cultivated variety of *Elettaria cardamomum* Maton Var *miniscula* Burk hill (*Zingiberaceae*), also variety which is mostly cultivated in Karnataka, has trailing racemes which grow horizontally along the ground and fruits are globular or oblong. The Mysore variety is distinguished by its larger leaf lamina and arching flower stems and larger longish fruits. It is mostly cultivated in Kerala and Tamilnadu. Hybrids between the Malabar and Mysore varieties, called Vazhukka, are also widely cultivated. There is also a wild variety native to Sri Lanka called long Ceylon wild. This is *Elettaria cardamomum* Maton Var *major* Thwaites, also called *Elettariamajor*. This giant type is commercially not important. Several species of Amomum produce cheap substitutes or false cardamom known as Nepal, Sikkim and Bengali, which are very inferior in quality.

Cultivation and processing

Seedlings which are six months old with 2-3 leaves are transplanted to a secondary nursery and planted 30-90 cm apart. Planting is done in June-July in the main field with 3-3.5 m spacing. The plants begin to yield from the third year onwards. Economic yields are obtained from the IV or V year. The peak period of flowering is during April – May and fruits take about 3-4 months to mature. Harvesting starts in August- September and the peak season for harvesting is October-November. The average yield is 100 kg/hectare. The cardamom fruits are harvested when they are almost fully ripe but still green in colour. Several pickings are made during the season. The freshly harvested fruits are washed in water and then dried in the sun or in artificially heated rooms or by mechanical dryers. On drying, the fruits loose 75% of their weight. Capsules treatedwith mild alkali (2% sodium carbonate solution) before drying retain their green colour and fetch a premium price.

The most important grades of cardamom in the trade are:

- Green: Green pods, artificially dried with or without alkali treatment.
- Sun dried: Light colored, dried in the sun.
- Bleached: Capsules bleached, chemically using either SO_2 or H_2O_2
- Decorticated: Hulled seeds.

Cardamom oil

The attractive flavour of cardamom is chiefly due to the volatile oil present in the seeds. The seeds contain on an average: moisture 8.3%, volatile oil 8.0%, fixed oil (NVEE) 2.9%, crude protein 10.3%, crude fibre 9.2% and mineral matter 8.5%. The volatile oil content of cardamom seeds varies from about 5% to 9%. The distilled oil of cardamom is colorless, volatile and easily soluble in alcohol. Oleoresins of cardamom prepared by solvent extraction of ground seeds and subsequent removal of solvent are a green liquid containing 70-75% volatile oil. It provides the full rich and warm flavour associated with the spice. It is marketed as such or after dilution with oil or propylene glycol.

HS Mehta Memorial Award Presentations

H8

Microwave assisted extraction of 6-Gingerols from fresh ginger

M Vedashree[1], Ravi Ramaswamy[2]& M Madhava Naidu[1]

Department of Spices & Flavour Science[1],
[2]Department of Traditional Foods & Sensory Science,
CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
*mmnaidu@cftri.res.in

Gingerol, the most abundant constituent of fresh ginger (*Zingiber officinale* Rosc.) has potent bio-active properties which decrease during drying process. The purpose of the study was to evaluate the optimum conditions applied by the microwave-assisted extraction (MAE) and fractionation to maximize the content of 6-gingerol extracted from ginger rhizomes. The ginger samples were washed thoroughly, sliced and dried in a hot air drier. The dried ginger was ground using Pin Mill (CADMILL) having a mesh diameter of 200 mm. The ginger powder was extracted using microwave-assisted extraction. Ethanol as a solvent was used and three different watts (400 W, 500 W and 600 W), temperatures (50◦C, 60◦C, 70◦C) and times (10 min., 20 min., 30 min.) were set for the extraction. The extracts collected under different conditions were then analyzed by TLC & HPLC. Ginger rhizomes with 90.17 ± 0.16% moisture content were dried using a cross flow dryer at 55 ± 2°C for 6 hours to achieve a moisture content of 10.54 ± 0.29%. After the drying process, [6] - gingerol content was reduced from 21.15 ± 0.13 to18.81 ± 0.15 mg/g on dry weight basis and best condition which has been optimized for MAE is 400 W, temp 70◦C at 10 min. process time, while RSM has been applied for MAE extracts, which is expressed by 2-D contour plots RSM graph, by keeping one variable constant also showed 600 W, temp 70◦C and 30 min. the higher yield.

H9

Cinnamon and turmeric dominate in antioxidant potential among four major spices

Saranya Balu, Sulfikarali Thondikkal, S Chindhu, A M Muneeb, N K Leela* & T John Zachariah

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*leela@spices.res.in

Antioxidants have a significant role in protecting the body from oxidative damage induced by free radicals. Natural antioxidants are drawing increasing attention due to their marked effects in the prevention of various oxidative stress associated diseases. Cinnamon, turmeric, ginger and black pepper are some of the spices used extensively in traditional medicines. The aim of present study was to evaluate the antioxidant potential of sequential extracts of these spices in relation to total phenols. Extracts were prepared by sequential soxhlet extraction of these spices using hexane, chloroform and methanol and antioxidant activity was determined by DPPH radical scavenging assay, phosphomolybdenum method (PM method) and ferric reducing power (FRP). DPPH radical scavenging activity of these extracts as determined by IC_{50} values, which ranged from 11.9 to 1500 µg/ml. Antioxidant activity by PM method and FRP varied from 0.30-2.99 MAAE/g and 0.27-1.56

MAAE/g of extract, respectively. The antioxidant potential of methanol extract of cinnamon and chloroform extract of turmeric as determined by DPPH and FRP methods was on par. By PM method chloroform extract of turmeric showed highest activity(2.99 MAAE/g), which was followed by methanol extract of cinnamon(2.34 MAAE/g). The antioxidant activity was also compared with the synthetic antioxidant, BHA which showed IC_{50} value of 5.4 µg/ml and 2.34 MAAE/g by FRP method and 3.68 MAAE/g by PM method.Total phenolic content of the extracts showed significant correlation with antioxidant activity.

Poster Presentations

P128

Effect of water replacement during fermentation period on the colour and quality of white pepper produced from green pepper

E Jayashree*, R Suseela Bhai, T John Zachariah, C D Divya & Josline Ann

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*ejayasree05@yahoo.com

Black pepper is a high value export oriented crop extensively used for flavouring food, beverages, medicines, cosmetics and perfumery. White pepper, the value added form of black pepper is used and consumed as food additive. Lab experiments on production of white pepper from green pepper were conducted at ICAR-Indian Institute of Spices Research during 2015 to determine the effect of water replacement during fermentation on the quality of white pepper. Experiments were conducted using freshly harvested green pepper following the treatments; 0% water (water unchanged), 25%, 50%, 75% and 100% water replacement daily until decortication was completed. A single factor completely randomized block design experiment was followed. The results indicated that, complete decortication of green pepper to white pepper was obtained on 6^{th} day for 100% water replacement. Total phenol activity was higher (68 mg/100 ml) in the treatment where the water was unchanged on the 6^{th} day of decortication and the lowest for 100% water replacement with a value of 18.27 mg/100 ml indicating that, total phenols were lost when water was removed daily. The Hunter colour values was highest for the treatment with 100% water replacement having L*, a* and b* values of 55.05, 6.61 and 19.56 and the lowest value for 0% water replacement with values of 45.16, 4.88 and 19.03, respectively. Dry recovery of white pepper with 100% water replacement was 22.8%. The essential oil, oleoresin and piperine content of white pepper obtained after 100% water replacement daily were 2.47%, 16.25% and 5.05%. The volatile constituents of essential oil of white pepper showed highest relative peak of 22.68% for α-limonene, followed by sabinene (13.78%) and β-pinene (9.05%). Surface microbial load varied from 1×10^3 to 81×10^1 CFU/mg. From the study it was observed that, to obtain white pepper of maximum whiteness, 100 per cent water replacement daily for 6 days would be essential.

P129

Development and performance evaluation of a mechanical unit for production of white pepper

E Jayashree*, R Suseela Bhai, T John Zachariah, Ravindra Naik, C D Divya & Dennis Abraham George

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*ejayasree05@yahoo.com

White pepper is the value added form obtained from either green or black pepper after the removal of outer skin. Traditionally this is achieved by soaking pepper in flowing water for few days and rubbing. In the present study, a mechanical unit was developed and evaluated for production of white pepper from black pepper. The prototype unit consisted of two parts, the fermentation and pulping units. The fermentation unit consisted of an outer cylindrical stainless steel tank mounted on three legs, water

circulation system with motor and drain valve. The pepper for fermentation was loaded in the inner perforated drum, placed in the outer drum and filled with water. The pulpingunit consisted of inner perforated stainless steel drum and outer stainless steel casing drum mounted on central stainless steel shaft. The outer drum was provided with a feed hopper. The central shaft is provided with 2 sets of nylon brushes. The shaft is connected to a pulley P1 with the help of two bearings. The pulley P2 is connected to 1 HP three phase motor. The trials on production of white pepper from black pepper was carried using black pepper (var: Panniyur-I) and the trial was conducted at ICAR-Indian Institute of Spices Research, Kozhikode. The black pepper was cleaned and graded in a mechanical grader having sieve of 3.5 mm perforations. Cleaned black pepper was transferred to the perforated fermentation tank and sufficient quantity of water was added. The water was changed every alternate days for 12 days. After 12 days, the outer skin was loosened and fermented pepper was washed and pulped in the pulping unit. The outer skin was removed and white pepper obtained was dried in the solar tunnel drier. The white pepper obtained had a dry recovery of 68.7% and the capacity of the pulping unit was 125 kg/h.

P130

Standardization of techniques for better rooting and growth of two noded orthotropic shoots in black pepper (*Piper nigrum* L.)

Nimisha Mathews*& G R Sulekha

Department of Plantation Crops & Spices,
College of Agriculture, KAU, Vellayani-695522, Thiruvananthapuram, Kerala
*nimishamathews21@gmail.com

Non-availability of vigorous disease-free productive rooted cuttings (planting material) is one of the reasons for low productivity of black pepper in India. A study was carried out to standardize techniques for profuse rooting and vigorous growth of orthotropic shoots of black pepper so as to produce quality planting material. The experiment was laid out in completely randomized design consisting of 10 treatments with 3 replications. All the treatments were imposed using 2 noded semi-hardwood cuttings of orthotropic shoots. Different treatments such as indole-3-butyric acid (500 ppm and 1000 ppm), common sugar solution (1%, 2% and 3%), arbuscular mycorrhizal fungi, *Azospirillum* (15%) and *Psuedomonas* (15%) were used for the rooting of two noded orthothropic shoots which were further planted in solarized potting mixture enriched with *Trichoderma* and PGPR Mix-11. Results showed that, two noded orthotropic cuttings of black pepper treated with *Azospirillum* (15%) were superior for most of the growth characters including, minimum number of days for sprouting, number of days for 50% sprouting, highest value for height of sprouted cuttings, leaf area and percentage success in establishment.

P131

Evaluation of antidiabetic activity of essential oil from the seeds of *Elettaria cardamomum* Maton with relevance to NIDDM therapy

Amrutha Chacko, RincyYesudas, S Lakshmanasenthil, G Suja, D Geetharamani[1],
M Murugan[2]& T Vinoth Kumar*

Department of Biotechnology, School of Biological Sciences,
CMS College of Science & Commerce, Coimbatore-641049, Tamil Nadu
[1]Department of Microbiology, Dr. NGP Arts & Science College, Coimbatore-641048, Tamil Nadu
[2]Cardamom Research Station, KAU, Pampadumpara-685553, Kerala
*vinothbiochem@gmail.com

NIDDM (Non-Insulin Dependent Diabetes Mellitus) is a global health problem affecting people worldwide. The present study was conducted to screen the alpha amylase and alpha glucosidase inhibitory activity of essential oil extracted from cardamom. Essential oil of cardamom at the concentrations, 0.5, 1.0, 2.0 and 4.0 µL exhibited 19, 31, 38 and 71% inhibition of alpha amylase and 9, 22, 34 and 62% inhibition of alpha glucosidase in a dose dependent manner. Active principles of essential oil determined by GC-MS analysis included, alpha-pinene, sabinene, 1,8-cineole, linalool, alpha-terpineol, trans-geraniol, alpha-terpinyl acetate and 1, 6, 10-dodecatrien-3-ol. *In silico* molecular docking analysis was carried out to identify the potent active principle responsible for antidiabetic activity. Among the major components tested, 1, 6, 10 dodecatrien-3-ol exhibited higher binding energy and interaction with the active sites of human alpha amylase and alpha glucosidase enzymes. It is concluded that, essential oil of cardamom possesses potent alpha amylase and alpha glucosidase inhibitory activity and identification of the active principle, 1, 6, 10-dodecatrien-3-ol for NIDDM therapy is first of its kind in the world.

P132

Quality attributes between traditional and instant method for ginger candy preparation

K Pradeep, K Shwetha, M Vedashree, Ravi Ramasamy[1]&M Madhava Naidu*

Department of Spices & Flavour Science,
[1]Department of Traditional Foods & Sensory Science,
CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
*mmnaidu@cftri.res.in

Ginger (*Zingiber officinale* Rosc.) preserve/candy, a ready-to-eat (RTE) food product, is also in great demand for use in confectionery. Ginger is the rhizomatous herbaceous tropical plant grown as an annual crop. Fresh ginger suffers from weight loss, shrinkage, sprouting and rotting during storage after 3 to 4 weeks. Processing fresh ginger for value added products would be a better measure to reduce the spoilage. The present study was undertaken to compare the quality attributes between traditional and instant method of candy preparation and to develop, optimize the process parameters for the production of ginger candy. The experimental parameters considered were cube thickness (3-5 mm) and blanching duration (10-15 min.) followed by dipping in 40°B and 75°B sugar solutions

containing 0.25% citric acid, respectively, for 1 and 2 h at 95°C and dried at 60°C for 1 h and the method is followed for traditional method by increasing 10°B every day upto 70°B. Quality attributes and process parameters was considered for this experiment and final products were evaluated for their proximate composition, textural properties, colour, TSS, acidity, taste score and overall acceptability. The optimum product qualities in terms of acidity (0.11-0.18%), taste score (7.98) and overall acceptability (8.07) were obtained for cube thickness of 5 mm and blanching time of 10-15 min. Our method has reduced the processing time by 50% from the regular traditional method.

P133

Experimental investigation on *Curcuma longa* L. in solar-biomass hybrid dryer

R Mahendiran, R Shreelavaniya*, S Kamaraj & S Pugalendhi

Department of Bioenergy,
Agricultural Engineering College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*energyengineershree@gmail.com

A walk-in type solar tunnel dryer integrated with biomass hot air generating system was designed and fabricated with movable trays and trolley for drying agro-products. Experiments were conducted to test the performance of the drier by drying turmeric (*Curcuma longa*) during summer under Coimbatore conditions. It was found that, during the load test, 1000 kg of fresh produce of turmeric, with an initial moisture content of 286 (db)% was dried to a final moisture content of 11.8 (db)% within 14 days compared to 21 days under open-sun drying system. Efficiency of the drier during its operation was found to be 32%. The quality analysis revealed that, with hybrid dryer, the curcumin content was 4.6% compared to 4.51% in open-sun drying. The overall thermal efficiency of hybrid drying system was 57.7%. It is concluded that, the newly developed drier with a simple system, can be manufactured locally and also can be used for drying other agricultural produces.

P134

Supercritical Fluid Extraction (SFE) of turmeric (*Curcuma longa* L.) showed different profileon quality traits

S Chindhu S, N K Leela*& T John Zachariah

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*leela@spices.res.in

Supercritical fluid extraction (SFE) is a technology for extraction and purification of a variety of compounds, particularly those with low volatility and susceptible to thermal degradation. Generally SFE extraction, yields extracts without toxic residues, with no degradation of active principles and high purity. In the present study, the composition of SFE extract of turmeric was compared with that of the conventional extraction methods. Dried turmeric (cv. Kedaram) rhizomes were extracted with compressed carbon dioxide at two different flow rates namely, 30 and 40 g/min. and pressure range of 20-30 MPa using methanol as modifier. The yield of SFE extract varied from 3.5-4.7%. The yield and

composition of SFE extracts varied with extraction pressure and flow rate. The volatiles and non-volatile constituents of the extract were analyzed by gas chromatography and HPLC. GC-MS profile of SFE extracts was compared with that of essential oil. The general constituents in turmeric oil, such as α-pinene, α-phellandrene, limonene, α-terpinolene and t-caryophyllene were not detected in SFE extracts. SFE extracts also showed variation in curcumin percentage and curcuminoid profile. Curcumin content in SFE extract ranged from 0.32% to1.7% which was lower than that of conventional method. Curcuminoid profile of SFE extracts also showed different pattern at different conditions.

P135

Effect of curing method on quality characters of turmeric rhizomes

M Dharini, C Indu Rani*, S Ganapathy & D Amirtham

Department of Food & Agricultural Process Engineering,
Agricultural Engineering College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*indunathan@gmail.com

Proper curing of fresh turmeric is highly essential for obtaining dry produce of high quality. A study was conducted to compare the effect of curing methods *viz*., water and steam boiling of fresh turmeric rhizomes on its quality constituents *viz.*, curcumin and oleoresin with the variety CO 2. The moisture, curcumin and oleoresin contents in raw turmeric were found to be 79%, 1.2% and 2.39%, respectively. After water and steam boiling, the moisture, curcumin and oleoresin contents of the rhizomes were 81%, 1.65%, 2.77% and 68%, 1.86%, 2.93%, respectively. Further, the cured rhizomes were subjected to sun drying (7% moisture). Steam boiled and sun dried rhizomes registered 4.01% curucmin and 8.25% oleoresin. Water boiled and sun dried rhizomes recorded 3.85% curcumin and 7.72% oleoresin. It is concluded that, curing of fresh turmeric rhizomes by steam boiling is the best method compared to water boiling in producing better quality product.

P136

Evaluation of bark yield and essential oil content of cinnamon

M Palanikumar*, J Prem Joshua, J D Nirmalatha & R Kannan

Horticultural Research Station, TNAU, Pechiparai-629161, Tamil Nadu
*mpkscientist@yahoo.co.in

The experiment was conducted at Horticultural Research Station Pechiparai during 2009-2012. The aim of the study was to find out the maximum bark yield and essential oil content in cinnamon. The experiment was statically analyzed with split plot design with two replications. The treatments were, length (L) 0.5 m (L1) and 1m (L2) and thickness of the stem (G)1-2 cm (G1), 2-3 cm (G2) and 5-6 cm (G3). Regarding thickness of the stem, G1 (1-2cm) recorded maximum dry weight of quills during 2009-2010, 2010-2011 and 2011-2012 (124.33 g, 129.23 g and132.98 g, respectively). Regarding length of the stem, L2 (1m) recorded maximum dry weight of quills during 2009-2012 (112.75

g,129.23 g and132.98 g, respectively). The treatment G2 (2-3 cm) recorded maximum essential oil per cent during 2009-2010, 2010-2011 and 2011-2012 (2.48 %,2.57% and 2.52%, respectively).The treatment L1 (0.5m) recorded maximum essential oil per cent during 2009-2012 (2.51%, 2.84% and 2.58%, respectively).

P137

Development and quality evaluation of flavourant from coriander seed

Siddharth Priyadarshi[1], Ramasamy Ravi[2]& M Madhava Naidu*[3]

[1]Academy of Scientific & Innovative Research (AcSIR), New Delhi
[2]Department of Traditional Food & Sensory Science,
[3]Department of Spice & Flavour Science,
CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
*mmnaidu@cftri.res.in

Coriander (*Coriandrum sativum* L.) is one of the major spice crops belonging to the family Apiaceae which possess various pharmaceutical applications. Coriander inhabits diverse applications in the food processing and allied industries apart from soaps, perfumes and flavours. The main objective of this paper was to formulate and evaluate the quality and antioxidant characteristics of coriander seed flavourant. Seed essential oil was extracted using Clevenger hydro-distillation. Soaked gum acacia was blended with essential oil and soluble starch. Oleoresin prepared in ethanol from coriander seed was added and mixed thoroughly. Gum acacia was added again and unified to get wet slurry followed by drying in hot air oven for ~3 h (50°C) and finally ground to obtain coriander flavourant. GC-MS, E-nose and radical scavenging activity were determined using standard protocols. The results were compared with the seed oleoresin. The flavour compounds identified by GC-MS in the coriander flavourant were linalool (70.12%), geranyl acetate (14.51%) and α-pinene (7.45%). E-nose head space analysis indicated that, the flavour profile generated from the coriander flavourant and oleoresins were distinctly different. The aroma profile generated by E-nose can be used for optimizing flavour characteristics in newer food applications. The result also demonstrated that, radical scavenging activity increased with the increase in concentration (50, 100 and 200 ppm) and no significant difference was observed in scavenging activity of the flavourant and oleoresin. This finding revealed the potential use of newer, cheaper and shelf-stable coriander flavourant.

P138

Effect of natural ageing on seed quality in fenugreek

Samita Kumari & S K Tehlan*

Department of Vegetable Science,
CCS Haryana Agricultural University, Hisar-125004, Haryana

Fenugreek (*Trigonella foenum-graecum*) is a multi-purpose crop and is utilized in one or other form as leafy vegetable, fodder and condiment. It is a well known fact that, quality seeds combining high viability and vigour ensure better establishment of crop in the field. A study was carried out on eleven genotypes of fenugreek with four seed lots of each genotype including fresh, one year, two years and three years old seed lot. The study revealed that, test weight (g), standard germination (%), seedling length (cm), seedling fresh and dry weight (mg), vigour index-I and II, viability (%), speed of emergence and seedling establishment (%) decreased, whereas, mean emergence time (days) and electrical conductivity (µS/cm/seed) of seed leachates increased with ageing period. The seeds of each genotype sustained germination upto two years thereafter; decreased below IMSCS (70%). Maximum germination was retained by the genotype, HM 548, followed by HM 292 and maximum loss of germination was observed in Hisar Mukta. Hence the genotype, HM 548 was found superior in respect of viability, vigour and storability under ambient conditions.

P139

Influence of different storage structures on storability of garlic

S Ajithkumar*, N K Hegde, Ravi Pujari &LaxmanKukanoor

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591218, Karnataka
*ajithkumar.592@gmail.com

An experiment was conducted to assess the storability of garlic bulbs under different storage structures duringApril to November 2013 at KRC College of Horticulture, Arabhavi, Karnataka. The treatments consisted of eight storage structures *viz*., bamboo battens thatched roof storage structure (sugarcane trash) without bottom ventilation (T_1), bamboo battens low cost storage structure with typha roofing with bottom and side ventilations (T_2), bamboo battens storage structure with AC sheet roofing with bottom and side ventilations (T_3), wooden battens storage structure with Mangalore tiles roofing and with bottom and side ventilations (T_4), wooden battens storage structure with galmenium roofing and with bottom side ventilation (T_5), wooden battens storage structure with AC sheet roofing and with bottom and side ventilations (T_6),gunny bag (T_7) and farmer's method (hanging of bulbs with top) (T_8). The genotype used for the study was AAS-2 and about 50 kg bulbs were stored in each structure with three replications. Among the different storage structures, significantly lower per cent weight loss, maximum TSS, higher per cent germination and seedling vigour were recorded when the bulbs were stored in wooden battens storage structure with AC sheet roofing and with bottom and side ventilations (T7).

P140

Pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.)

B R Kumara, Shankargoud Patil & Uttam Tripura*

Department of Plantation, Spices, Medicinal & Aromatic Crops,
KRC College of Horticulture, UHS, Arabhavi-591310, Karnataka
*uttam_uhs@yahoo.in

Field experimentswere conducted during *rabi* 2011-2012 at KRC College of Horticulture, Arabhavi to study the effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic. The field trials were laid out in a randomized block design with nine treatments and three replications. Pre-harvest sprays of growth regulators and chemicals significantly influenced the plant height, number of leaves per plant, leaf length and breadth and plant diameter. However, the bulb yield was not affected by pre-harvest sprays of growth regulators and chemicals. Pre-harvest sprays of growth regulators and chemicals significantly reduced the physiological loss in weight upto 180 days of storage. Significantly least cumulative physiological loss in weight (30.67%) was recorded in T_2 (maleic hydrazide 2500 ppm + carbendazim 1000 ppm) and highest cumulative physiological loss in weight (39.57%) was recorded in T_9 (unsprayed control) at 180 days of storage. All the growth regulators and chemicals significantly enhanced the recovery of healthy cloves compared to control.

P141

Evaluation of garlic genotypes and effect of storage containers on storage behaviour of garlic cv. AAS 2 (Vannur local)

Chandrashekar Madannavar &Shankargouda Patil*

University of Horticultural Sciences, Bagalkot-587103, Karnataka
*patils234@yahoo.in

Experiments were conducted to evaluate garlic genotypes for growth, yield and to study the effect of storage containers on storage behaviour in cv. AAS 2 (Vannur Local), at UHS, Bagalkot. Among the sixteen genotypes evaluated, highest plant height was recorded in AAS 9 (51.35 cm) and significantly higher bulb yield in AAS 2 (4.13 t/ha). Significantly higher sulphur and volatile oil contents were observed in the genotype, G 282 (0.065% and 0.20%, respectively). Among different storage containers, the least PLW (4.23%, 11.33% and 18.44%) was observed when the bulbs were stored in ventilated polyethylene bags (20% vents) of 200 gauge at 30, 60 and 90 days of storage, respectively and maximum TSS (30.39^{o}Brix) was recorded in garlic bulbs hung on bamboo poles at 30 days after storage. At 60 and 90 days after storage, maximum TSS was recorded in garlic bulbs stored in nylon net bags (27.73^{o}Brix and 27.92^{o}Brix, respectively). In the present study, genotypes G 10, AAS 1, AAS 2, G 282 and G 275 were found promising under GLBC? conditions with better growth, yield and quality. Among different storage treatments, garlic bulbs hung on bamboo poles recorded no sprouting and rotting, with minimum loss due to storage pests.

P142

Quantitative determination of bioactive components in rhizome of *Curcuma caesia* using gas chromatography–mass spectrometry

R Chitra*, R Priya & J Suresh

Department of Spices & Plantation Crops,
Horticulture College & Research Institute,TNAU, Coimbatore-641003, Tamil Nadu
*chitra.varadharaj@gmail.com

Curcuma caesia is commonly known as Kali Haldi and it belongs to the family Zingiberaceae. This herb is available throughout North-East, Central India, Papi Hills of East Godavari, West Godavariand Andhra Pradesh. In the traditional system of medicines, fresh and dried rhizomes of *C.caesia* are used in treating leucoderma, asthma, tumours, piles, bronchitis, bruises *etc*. Hence, the acetone extract of rhizome of *C. caesia* was investigated for its bioactive components using Gas Chromatography-Mass Spectrometry (GC-MS) analysis. In the present study, fifty eight compounds were identified. The major compounds identified were, 2-pentanone, 4-hydroxy-4-methyl acid(7.68%), 4,5,6,6a-tetrahydro-2(1H)-pentalenone (7.92%), trans-2-decen-1-ol (4.04%), 5-benzofuranacetic acid (3.85%), hexadecanoic acid (2.59%), 3,9-dodecadiyne (2.55%) and n-decanoic acid (2.51%). The biological activities of each of the identified phyto-components ranged from antimicrobial, antioxidant to antitumoral activities. The nature of the identified compounds was mostly organic acids. The research findings have shown that, the rhizome of *C. caesia* is extensively rich in secondary metabolites. These findings have provided scientific basis to the ethnomedical usage of the plant. However, isolation of the individual phyto-chemical constituents, subjecting it to biological activity and toxicity profile will give fruitful results.

P143

Package of equipment for vinegar making from *Garcinia cambogia*

Ravindra Naik* & S J K Annamalai

ICAR-Central Institute of Agricultural Engineering, Regional Centre,
Coimbatore-641007, Tamil Nadu
*naikravindra@gmail.com

Garcinia cambogia is a minor forest produce which is excessively available in Western Ghats. The juice obtained from ripe *Garcinia* fruits is converted to vinegar which is used as a souring agent after concentration. Package of equipment *viz*., juicer/grinder, juice squeezer and juice concentration unit was developed at ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore, Tamil nadu to make vinegar from ripe *Garcinia* fruits. For extraction of juice, the fruits were reduced to fine size after deseeding. This was performed by high speed juicer/grinder (2800 rpm) with 2 HP single/three phase motor. The juicer/grinder was made of stainless steel with a set of six blades fixed to the rotating drive shaft with tight lid. Provision was made to tilt the juicer for easy unloading after grinding. The capacity of the unit was 4 kg/batch and 40-45 kg/h. The ground paste of juice and fibre is fed into juice squeezer for extraction of juice. The juice extraction in this equipment is hygienic,

without direct contact of human hands. The capacity of this unit is 2 kg/batch. The extracted juice is converted to vinegar by concentrating using a tilting type concentrator of about 30 liters capacity, made of stainless steel. The concentrator is operated by 1 HP single phase motor and the fuel used is LPG. It requires about 4 hours to convert 30 liters of juice to vinegar.

P144

Design and development of a forced flow type dryer for curry leaf

Dawn C P Ambrose*, S J K Annamalai & Ravindra Naik

ICAR-Central Institute of Agricultural Engineering, Regional Centre,
Coimbatore-641007, Tamil Nadu
*dawncp@yahoo.com

Curry leaf is dried under sun and used in masala industries at Coimbatore. Sun drying results in inferior quality in terms of colour and aroma. In order to upgrade the method of drying in a controlled condition for good quality end product, an attempt was made to design and develop a forced flow type mechanical dryer for curry leaf based on preliminary laboratory studies. The overall dimension of the dryer was 900 x 900 x 16500 mm. The dryer consisted of a drying chamber, plenum chamber, heating chamber and a blower, driven by 2 HP motor.The performance of the dryer was evaluated for drying curry leaves. Moisture content of curry leaves decreased from about 67% to about 5% (w.b.) in approximately 6 hours for drying 50 kg of fresh curry leaf. The thermal efficiency of the dryer was found to be 45.6% and the heat utilization factor was 0.32. The quality of the dried curry leaf in terms of volatile oil content, colour and rehydration ratio was found to be good.

P145

Studies on use of growth regulator and chemicals for shelf life extension in curry leaf *(Murraya koenigii* Spreng)

I Geethalakshmi*, T Thangaraj, G Sathish[1]& M S Marichamy[2]

Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
[1]Horticultural College & Research Institute, TNAU, Periyakulam-625604, Tamil Nadu
[2]PAJANCOA, Karaikal UT of Puducherry-3, Tamil Nadu
*geethahorty@yahoo.in

Curry leaf (*Murraya koenigii* Spreng) is a perennial nutritious leafy spice crop. The crop is mostly in cultivation in southern parts of India. Besides being a spice, curry leaf plays a major role in the ayurveda system of medicine due to its medicinal properties. There is a need to spread the research area on pre and post harvest handling in view of its enhanced global demand. In this view, studies on curry leaf were carried out at the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, during 1997-99 to find out the use of chemicals for shelf life extension in curry leaf. Among the various growth regulators and chemicals tested, gibberellic acid at 10 ppm recorded a maximum extension of shelf life (6 days) with the least physiological loss in weight (24 per cent),

maximum chlorophyll retention (0.58 mg/g), maximum protein content (0.543 mg g^{-1}) and maximum essential oil content (0.15 per cent), which was closely followed by benzyl adenine. Among the various chemicals tested, tartaric acid at 150 ppm recorded a minimum physiological loss in weight (24.02), maximum protein content (0.584 mg g^{-1}), maximum essential oil content (0.154 per cent) with a shelf life of 6 days closely followed by sodium bicarbonate at 50 ppm.

P146

Isolation and characterization of *Zingiber zerumbet* starch

K Shwetha, K Pradeep, M Vedhashree, Ravi Ramsamy[1] & M Madhava Naidu*

Department of Spices & Flavour Science,
[1]Department of Traditional Foods & Sensory Science,
CSIR-Central Food Technological Research Institute, Mysore-570020, Karnataka
*mmnaidu@cftri.res.in

Food industry needs have become more complex with processing of more elaborate dishes; this is forcing the starch sector to search for new products. Introducing new starch sources with industrially interesting processing features has been attracting the attention of industrialists as it could influence the world market. Such new crop sources include *Zingiber zerumbet,* a stem less herb with long fleshy fibrous roots, terminating in oblong tubers, native to India. Rhizomes were dried, powdered and starch was isolated. Proximate composition such as moisture, ash, fat, crude protein, sugars and starch content in *Z. zerumbet* starch were determined by AACC standard methods. The total dietary fibre (TDF) including both soluble and insoluble dietary fibers were estimated as described in AOAC method. The granules were disc-shaped as well as ovoid and average granule size was 26.15-3.5 µm in length and 16.9-4.8 µm in width with a thickness of about 3 µm. The extracted starch was analyzed and the composition was moisture 12.5%, protein 1%, fat 1.48%, dietary fibre insoluble 7.44% and soluble fibre 1.25%. It contained 81% starch by DNS method and amylose content in the starch was about 31±0.95%. The pasting and thermal property analyzes indicated that, *zerumbet* starch has high gelatinization temperature (88-95°C). It would, therefore, constitute a satisfactory texture agent for foods. Functionality of *zerumbet* starch being comparable to those of other tuber/rhizome starches.

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Analysis of varietal profile, sourcing pattern and demand for black pepper planting material in Kerala: Implications for supply systems policy

Lijo Thomas*, K Rejula & P Rajeev

ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
[1]Agricultural Technology Application Research Institute, Bengaluru, Karnataka
*lijo@spices.res.in

The planting material supply system is a critical component in black pepper which can have significant impact on genetic improvement through varietal spread and adoption. In this study, information on

the varietal profile, potential demand, varietal sourcing pattern and socio-economic status of 120 randomly selected farmers from three districts of Kerala were collected using a structured questionnaire. The data were analyzed for generating information on the existing varietal pattern and age profile of the existing black pepper vines. The disaggregated data on new plantings with respect to the source of planting material and rate of replanting were also analyzed. The divergence between the extant varietal profile and the demand pattern in the new planting undertaken indicated a slow shift from traditional varieties to modern varieties. The use of technology inputs was low, with only 25.7% of the respondents reporting use of fungicides/pesticides. The estimation of prospective demand for black pepper planting material indicated significant potential for intensification of black pepper cultivation. An intensification potential of 168 per cent was measured in the study. About 46 per cent of the farmers reported replanting of vines lost to pest and diseases. The age profile, technology adoption status, rate of re-planting and shift in varietal profile holds significance for the planting material supply system. The study brings out the lacunae in the existing planting material supply system and highlights the need for innovative policies for establishing a strong and efficient network for ensuring easy availability of desired planting material.

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Growth dynamics of pepper in India

S Varadha Raj, Reeja Wilson, M Chinnadurai & CK Soujanya[1]

Department of Agricultural Economics,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
[1]CARDS, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu

Black pepper contributes 41% of the total foreign exchange and India contributes 15 per cent of the world production of which, Kerala contributes 95% of production. Time series data on area, production, productivity and export of black pepper during 1981-2014 were taken for the study. The objective of the paper was to assess the trend and decadal comparison of area, production, productivity and export of black pepper. The area and production of pepper had almost doubled during 1981-2014. The main contributing states were Kerala, Karnataka and Tamil Nadu. USA, UK and China were the major importers of Indian pepper. The pepper production growth will be at 5.1% for the next one decade (2010-2020) and will increase steadily to about 80 thousand tonnes by 2020 with 4.1% growth in area. Kerala was dominant in pepper production in the pre- liberalization period; Karnataka and Tamil Nadu are dominant in the post-liberalization period. The price of pepper was higher in September and October than other months. Farmers can plan their production decisions to reap this price advantage.

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Economics of production and marketing of small cardamom in Kerala

A K Noushad & K R Karunakaran

Department of Agricultural Economics, CARDS,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu

The study on economics of production and marketing of small cardamom was carried out in Idukki and Wayanad districts of Kerala with the objectives *viz*., (i) to measure the growth and instability in area, production, productivity and export between pre-WTO and post-WTO periods, (ii) to analyze the resource use and technical efficiencies of production, (iii) to find out the major constraints in production and marketing, (iv) to estimate the price spread and marketing efficiency for two major marketing channels and to explore the export from India and (v) to suggest policy measures to curtail the production and marketing constraints faced by farmers. In Kerala, area under small cardamom was found decreasing throughout the last four decades, with higher growth rate of production and productivity in post-WTO compared to pre-WTO period. The instability in export from India was low during post-WTO than pre-WTO period. Resource use efficiency analysis indicated that, labour and chemical were the most over utilized resources. In Idukki, more than 57 per cent of farmers had efficiency level of above 95 per cent and in Wayanad around 28 per cent of farmers were technically efficient at a level below 65 per cent. The two major marketing channels identified were (i) producer, domestic traders, wholesalers, exporter, consumer and (ii) producer, auctioner, licensed traders, wholesalers, exporter, consumers. In Idukki, the major production constraints were the incidence of high pest and diseases and in Wayanad, it was the unavailability of HYV which suits to climatic conditions. High price volatility was found to be the major marketing constraint.

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Cyclical price behaviour in turmeric

D Murugananthi*, K M Shivakumar& A Rohini

Department of Social Sciences,
Agricultural College & Research Institute, TNAU, Killikulam-628252, Tamil Nadu
*murugananthi@gmail.com

This paper provides an insight into the price behaviour of turmeric in Tamil Nadu by analyzing price data for 26 years (1986-2012) in order to trace the presence of price cycles using Bry-Boschan algorithm. Market integration in three major turmeric production and marketing centers of South India namely Erode, Nizamabad and Duggirala was analyzed by using Johansen's multiple co-integration framework. Turmeric price exhibited a cyclical behaviour with a length of 5 years approximately (peak to peak). The time spent in slump was higher than time spent in boom. In this case, price cycles had a consistent shape, which provided scope for forecasting turmeric price. The study revealed the existence of better integration between the three selected markets. Considering the price cycles and forecasted price, suitable guidelines could be formulated to minimize the loss to the farmers due to price fluctuations. This could help the farmers in adopting informed decisions on

sowing and marketing of turmeric. Since all the selected markets exhibited integration, the policies could be generalized for major production centers as well.

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Impact of farmer participatory approach on adoption of IPM technologies and yield enhancement of turmeric growers

B Geetha

Krishi Vigyan Kendra, TNAU, Sandhiyur-636203, Salem, Tamil Nadu
geethaentomology@yahoo.com

Integrated pest and disease management technologies with special emphasis on biological control were focused through farmer's participatory approach through front line demonstrations, field diagnostic visits, mass trainings and feedback meetings in five villages *viz*., Sandhiyur, Attayampatti, Kuralnatham, Thippampatti, Kammalapatti and Panamarathupatty of Salem district. IPM technologies of soil application of neem cake, spraying of neem oil (3%), neem soap, neem seed kernal extract (5%), along with parasitoids, predators, seed rhizome treatment and soil application with *Trichoderma viride* and *Pseudomonas fluorescens,* drip application of liquid *Pseudomonas* and *Paeciliomyces lilacinus* were adopted. Sixty IPM demonstrations were laid out during 2013-15. Highest yield of 24.2 tonnes/ha with the average yield of 22 tonnes/ha and an yield increase of 38.18% were noticed in IPM plots compared to non-IPM plots (13.6 tonnes/ha). Thrips and stem borer incidence were 4 to 8.2% in IPM plots while it was 16.8 to 22% in non-IPM plots. The incidence of leaf spot and blight (15.5%) and rhizome rot (12.2%) were less in IPM plots while, heavy incidences of diseases *viz*., leaf spot, blight (55.5%) and rhizome rot (48.6%) were recorded in non-IPM plots. The farmers who adopted IPM saved 2 sprays of pesticides and 3 sprays of fungicides and obtained a net income of Rs. 274000/ha with BC ratio of 3.97 compared to non-IPM farmers whose net income was Rs. 133600/ha. The horizontal spread of the technology was 80%, with the achievement of motivation behaviour, improved decision making and improved economic and social conditions of IPM farmers.

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Mapping and analysis of chilli value chain in South Tamil Nadu

K Divya*, S D Sivakumar & K Mahendran

Department of Agricultural & Rural Management,
Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*divyatnau@gmail.com

A study was conducted to map the existing major value chains and to understand the core processors and actors involved in the activities of the chain in three major chilli growing districts in Tamil Nadu. In the study, 160 sample farmers were selected using random sampling technique. The data were also collected from the stakeholders of major chilli value chains in the study area. The study indicated that, input suppliers, farmers, village traders, commission agents, wholesalers and retailers were the major actors. The processing firms played a major role in value chain and they had contract with farmers. To ensure quality of the produce, processing firms provided a set of Good Agricultural Practices to the

farmers. Major share of contract farmers adopted GAP technologies and field sanitation practices.In chilli value chain I, value addition cost incurred by farmers accounted to 37.78 %, followed by wholesaler (36.33%) and commission agent (17.22%). In the chilli powder value chain I, 55.31% of value addition was performed by processing firms, followed by farmers (44.69%). Marketability (69.61) was the most important advantage and increase in production cost (70) by adopting GAP was the major problem for contract farming. The average wastage was higher at producer level (56.3%), followed by processor (32.71%) and commission agents (10.98%). Volume of spoilage at producer level and average wastage was 8.76 kg per quintal (46.01%), followed by wholesaler (32.62%) and village trader (6.51%). Rainfall or humid weather at farmer's level and high moisture content of chilli at intermediary level were the foremost reasons for the post harvest loss of dry chilli.

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A study on production and marketing of curry leaves in Coimbatore district

S Kowshika*, T Samsai & S D Sivakumar

Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu
*koushi.sks@gmail.com

The curry tree (*Murraya koenigii*) is native to India and is extensively grown in Southern India and used due to its authentic flavour. Curry leaf plays an important role as a condiment in the culinary preparation of South Indian dishes. It is cultivated in field scale in Coimbatore, Erode, Madurai, Salem and Trichy districts of Tamil Nadu. In this paper, the economics of cultivation, marketing, problems and prospects in the production and marketing of curry leaves are analyzed. A sample of 40 farmers and 10 local traders were selected from Mettupalayam taluk, Coimbatore district for collection of data using interview schedules. The results of the study indicated that, on an average, farmers in the study area incurred Rs.101201 per acre as cost of cultivation in growing curry leaves and in turn realized, Rs. 143526 per acre. The net profit from one acre was Rs. 42325.The major problems confronted by the farmers in production of curry leaves were labour scarcity and infestation of pest (red lice) and disease incidence (leaf spot). The major problem in marketing of curry leaves was price fluctuation. The price of curry leaf at the farm gate ranged from Rs. 5 to Rs. 45 per Kg. The price was maximum during February to April and minimum during November to January.

Session IV

Quality Planting Material Production

Lead Lectures

L12

Nursery accreditation and quality planting material production in spices

Homey Cheriyan* & Femina

Directorate of Arecanut & Spices Development
Ministry of Agriculture, Government of India, Kozhikode-673005, Kerala
*homeycheriyan@yahoo.co.in

Spices are high-value and low-volume commodities of commerce. Spices play an important role in the food industry world over. The annual world import of spices is on the increase. During the period from 2001 to 2010, world import of spices has increased from 2.7 billion US $ to 5.8 billion US $, with an annual growth rate of 7.8%. Indian spice production also increased to commensurate with the growing global demand for spices. The production of spices in the country has increased from 3.8 million tonnes in 2005-06 to 6.0 million tonnes in 2013-14 with annual growth rate of 6%. Exports of spices from India increased substantially and have crossed 2 billion US $ during 2011-12. The export earnings showed a spectacular growth during the period from 2005-06 to 2013-14 as the earnings increased from 59.9 million US $ to 2267.67 million US $. However the national productivity of all major spices is much lower than the average potential yield recorded in the crop. e.g. productivity of pepper in India is 357 kg/ha where as in Thailand and in Vietnam it is recorded more than 1500 kg/ha. Productivity of ginger in India is 3.5 tonnes/ha whereas that in China is recorded at 10 tonnes/ha. Similarly productivity of garlic in India is 5 tonnes/ha, which is of no match with that of China which is in the order of 15 tonnes/ha.

The major reasons identified for the low productivity arethe poor coverage of area under high yielding varieties and poor management practices followed besides, the declining land area for agriculture.The poor coverage of area under high yielding varieties is in turn attributed to the non-availability of quality planting materials of improved varieties at the farmers' level.

Importance of planting material in spices

Quality planting material is of paramount importance in spice cultivation. Both yield and quality are important for the success of spice cultivation. Hence, those varieties which have high yield and has the required intrinsic quality alone succeeds. Besides the choice of variety, the health of planting material also plays a role in the productivity of the plant. The quality of the planting material has a special significance, especially in perennial spice crops which have a long juvenile/ gestation phase and any mistake committed by the grower in the initial stage, in both the choice and health of the planting material, will result in enormous loss in later stages. Hence, genuineness and health of the planting material is the pre-requisite to the success of any spice development initiative.

Considering the growing demand of spices, planting material production was the major programme undertaken under the Centrally Sponsored Schemes of the Government of India during the initial Five year plans. These programmes were intensified with higher financial allocation since VIII Plan under Centrally Sponsored Scheme, with the introduction of "Integrated Programme for Development of Spices". The strategy adopted for VIII and IX Plan was to enhance the production of nucleus planting materials of improved varieties of spices at the source station itself, which would be utilized for mass multiplication at the State Agricultural Department farms. Accordingly, large scale multiplication of quality planting materials was taken up with the State Agriculture/Horticulture Departments, State Farming Corporation of India, National Horticulture Research and Development Foundation (NHRDF).

These programmes were helpful in creating an indirect impact in production of various spices in the country. However, in the present scenario, with the increased demand in planting materials, it is estimated that only 30% to 40% of the demand for planting material in different horticultural corps is being met by the existing infrastructure in public domain. Much of the dependence is on private source of which majority of the units are not regulated or monitored in most of the states. Hence, the farmers have no access to the genuine disease-free, certified planting materials in different spice crops and as a result, suffer with respect to production, productivity and quality of the produce.

Planting material requirement

The tentative requirement of planting materials for the next five years is given in Table 1.

Table 1. Tentative requirement of planting materials for next five years

Crop	Unit	Planting material /ha	2015-16	2016-17	2017-18	2018-19	2019-20
Vegetatively propagated							
Black pepper	No.s in lakhs	0.011	164	167	171	174	177
Ginger	tonnes	1.4	203062	207123	211265	215491	219800
Turmeric	tonnes	2.00	474218	483703	493377	503244	513309
Garlic	tonnes	0.50	117626	11979	122379	124826	127322
Nutmeg	No.s in lakhs	0.0015	0.602	0.614	0.626	0.639	0.651
Clove	No.s in lakhs	0.002	0.087	0.089	0.090	0.092	0.094
Cinnamon	No.s in lakhs	0.00275	0.017	0.017	0.018	0.018	0.018
Tamarind	No.s in lakhs	0.001	1.155	1.178	1.202	1.226	1.250
Seed propagated							
Chilli	tonnes	0.002	1585	1616	1649	1682	1715
Coriander	tonnes	0.020	9301	9487	9676	9870	10067
Cumin	tonnes	0.015	13399	13667	13940	14219	14503
Fennel	tonnes	0.010	563	575	586	598	610
Fenugreek	tonnes	0.025	1715	1748	1783	1819	1855

(**Note:** Projection is based on considering an annual growth rate of 2% in area and replanting of 10% of existing area with improved varieties in black pepper and annual growth rate of 2% in area in other crops)

As per the estimates, only 18 to 20% of the seed is replaced in seed spices sector. This should increase substantially to improve both productivity and quality of the seed spices cultivated.

Accreditation of spice nurseries

The planting material requirement of the spice growers is mainly met by nurseries established under State Department of Horticulture/Agriculture, the SAUs and ICAR Institutes at present. However, these nurseries in public domain provide only 30-40% of the demand for planting material. The major part of the demand is met by the unregulated private nurseries, which lacks modern infrastructure such as green house, mist chamber, efficient nursery tools and gadget, implements and machinery. Accreditation of nursery is an important step to regulate the quality of planting materials supplied by these nurseries.

Accredited nurseries

During the Eleventh Plan period, National Horticulture Board started programme on accreditation of nurseries with the aim to improve quality of planting materials being supplied to the farmers. As per NHB website, at present there are more than 1500 accredited nurseries in fruits, plantation crops and spices, the ones catering the spices sector are only 26 numbers, details of which are given in table below.

Table 2. No. of accredited nurseries in spice sector

	Spices	**No. of accredited nursery**	**State**	**Production capacity (No.)**
1.	Black pepper	17	Karnataka - 12 Kerala - 2 Maharashtra - 2 Tamil Nadu - 1	22,60,000
2.	Cinnamon	2	Maharashtra - 2	10,200
3.	Nutmeg	7	Karnataka – 1 Kerala – 5 Maharashtra - 1	3,23,120

From 2014-15 DASD has been authorized by the Ministry of Agriculture, Govt. of India for accrediting spice nurseries. Accreditation of nurseries is an important step to ensure availability of quality planting material to the farmers. As per the MIDH norms, planting materials need to be procured only from accredited nurseries for all government programmes.

The three important aspects to define a model nursery in a comprehensive manner are,(a) The nursery infrastructure, (b) Quality parameter of planting material adopted and (c) Adoption of good nursery management practices. A recognized model nursery should function as a reliable source of supply of quality planting material for spice crops.With a view to ensure availability of good quality planting material as outlined above, DASD has started a system of accreditation of spicenurseries and such nurseries will be displayed in the website of the Directorate for knowledge of the farmers.

The nursery infrastructure

Different features of a model nursery

- **Mother blocks** – Consists of *elite* plants of the recommended varieties,closely planted and managed for regular supply of scion shoots/shoots for propagation.
- **Polyhouse** – A structure created with polyethylene sheets with humidity and temperature control mechanism primarily used for keeping freshly grafted/budded plants so as to get early union and high success rate.
- **Shadenet** – Simple structure stretched for providing partial shade to mother plants and for keeping young plants for hardening. Shade net alsogives protection against frost and hailstorm*etc*.
- **Nethouse -** Insect proof structure stretched over mother plants/newly propagated plants to avoid insect attack and viral contamination.

- **Wind breaks –** A group of fast growing fruit and forest plants which are raised along the boundaries of the field. Such grown-up trees can minimize the wind velocity and to some extent can reduce the level of harshness during the extreme conditions of high and low temperature.

Existing infrastructure for planting material production in spices

Production of planting materials is being done both in public and private sectors. There are different agencies, which do multiply plants, however, there is a major concern about the authenticity and quality of plant material supplied under private sector.

a) State Govt. nurseries / farms

Nurseries have been established by the State Governments to cater to the planting material needs of the farming community depending on the crops commercially cultivated there. At present, there are over 100 such nurseries/units in operation in about 15 states. These nurseries mainly multiply horticultural and social forestry plants. Spices receive little attention in these nurseries. During the recently concluded National Consultative Meet on Planting Material Production of Ginger & Turmeric, none of the states reported having taken up planting material production of ginger and turmeric in the State Government farms. It was conceded that, major share of the planting material of ginger and turmeric required in the country are obtained through farmer to farmer exchange.

b) ICAR institutes

Planting material for different spice crops is also being produced by several ICAR institutes like Indian Institute of Spices Research, Calicut;National Research Centre for Seed Spices, Ajmer, Central Institute for Arid Horticulture, Bikaner; Central Institute for Sub-Tropical Horticulture, Lucknow; Central Institute for Temperate Horticulture, Srinagar *etc*.

c) State Agricultural Universities (SAUs)

Almost all the State Agricultural Universities have their own nurseries/farms for supply of planting materials of spices and plantation crops. These universities through their nurseries arrange for multiplication of released/recommended varieties in spices. However, there is a wide gap in demand and supply of recently released varieties in certain crops.

d) Private nurseries

During the beginning of Eleventh plan period, the report of the Working Group on Horticulture stated that, there are over 6,000 registered small and medium scale nurseries in the country. Large nurseries were around 100 in the country. Number of nurseries has increased because of the assistance provided by NHM, however, the availability of planting materials of spices is still far below the requirement.

Table 3. Available nurseries in public and private domain for various horticultural crops in the country as recorded in the report of the Working Group on Horticulture for XI Plan

Sl. No.	State	Number of nurseries			Total
		Public sector	SAUs/ICAR Institutes	Private sector	
1.	Andhra Pradesh	57	-	913	970
2.	Arunachal Pradesh	20	-	37	57
3.	Assam	4	-	82	86
4.	Bihar	127	27	126	280
5.	Chhattisgarh	106	1	-	107
6.	Goa	-	-	-	-
7.	Gujarat	23	14	335	372
8.	Haryana	25	1	36	62
9.	Himachal Pradesh	78	-	648	726
10.	Jammu & Kashmir	77	-	348	425
11.	Jharkhand	157	2	-	159
12.	Karnataka	28	-	15	43
13.	Kerala	64	26	30	120
14.	Maharashtra	136	42	1,300	1478
15.	Madhya Pradesh	270	-	-	270
16.	Manipur	12	-	41	53
17.	Meghalaya	31	-	-	31
18.	Mizoram	9	-	8	17
19.	Nagaland	2	-	15	17
20.	Odisha	92	-	62	154
21.	Punjab	24	7	39	70
22.	Rajasthan	27	6	22	55
23.	Sikkim	-	-	-	-
24.	Tamil Nadu	76		285	361
25.	Tripura	41	-	9	50
26.	Uttar Pradesh	79	-	-	79
27.	Uttrakhand	23	12	176	211
28.	West Bengal	6	-	80	86
	Total	**1594**	**138**	**4607**	**6339**

Nurseries established under NHM/MIDH

Based on the recommendations of the Core Group, National Horticulture Mission, which was launched during 2005-06, gave focused attention to the production of good quality planting materials of horticulture crops and efforts were made to create necessary infrastructure in the form of nurseries like model nursery, hi-tech nursery, small nursery and upgradation of existing nurseries *etc*. During the period from 2005-06 to 2014-15, 2939 nurseries were established in various states to ensure the availability of quality planting materials.

Table 4. Nurseries established under NHM (state-wise)

S. No.	State	No. of nurseries established
1	Andaman & Nicobar	30
2	Andhra Pradesh	152
3	Bihar	93
4	Chhattisgarh	171
5	Delhi	25
6	Goa	9
7	Gujarat	89
8	Haryana	67
9	Jharkhand	142
10	Karnataka	504
11	Kerala	357
12	Madhya Pradesh	197
13	Maharashtra	186
14	Odisha	222
15	Pondicherry	4
16	Punjab	8
17	Rajasthan	135
18	Tamil Nadu	220
19	Telangana	1
20	Uttar Pradesh	182
21	West Bengal	145
	Total	**2939**

Source:www.nhm.nic.inaccessed on 25 Nov 2015

Planting material production under NHM/MIDH

With the launch of National Horticulture Mission during 2005-06, the availability and supply of good quality planting materials received focused attention and efforts are in to create necessary infrastructure in the form of nurseries and upgradation of existing tissue culture units. Since it is not possible to meet the whole demand of planting material through public domain alone, it was found necessary to encourage private participation in the sector. To ensure that only quality planting material reach the farmers, it was found necessary that a uniform regulatory mechanism should be established in the country.

The MIDH gave top priority to the production and distribution of good quality planting materials of horticulture crops including spices. To meet the requirement of planting materials (for bringing additional area under improved varieties of horticultural crops and for rejuvenation programme for old / senile plantations), assistance is provided for setting up new hi-tech nurseries and small nurseries under the public as well as private sector. Assistance is also provided for upgradation of existing nurseries. The MIDH also supports planting material production of spices.

Hi-tech nurseries

Hi-tech nurseries will have an area between 1to 4 ha with a capacity to produce 50000 plants per ha of mandated crops. The plants produced will be certified for the quality. The infrastructure support includes, proper fencing, scion/mother block of improved varieties, root stock block, net house, irrigation facilities, hi-tech green house having insect proof netting on sides and fogging and misting systems, hardening/maintenance in insect-proof net house with light screening properties and sprinkler irrigation system, pump house to provide sufficient irrigation to the plants and water storage tank to meet at least 2 days requirement and soil solarization-steam sterilization system with boilers. Rate of assistance for establishing hi-tech nursery is Rs. 25 lakhs/ha. 100% assistance is provided for public sector. For private sector, credit linked back-ended subsidy @40% of cost, subject to a maximum of Rs. 40 lakh/unit, for a maximum of 4 ha will be provided.

Small nurseries

Small nurseries with an area up to one ha will have provision for naturally ventilated green houses and net houses. Small nurseries need to produce 25000 plants of the mandated perennial vegetatively propagated plants per year, duly certified for its quality. Nurseries will also be regulated under legislation in force relating to seeds and planting material. Efforts will be made to establish nurseries at production cluster itself. Nurseries will be encouraged to go in for accreditation. Planting material for MIDH programme will be procured only from accredited nurseries. Rate of assistance for establishing small nursery is Rs. 15 lakhs/ha.100% cost is provided for public sector. For private sector, credit linked back-ended subsidy, subject to a maximum ofRs. 7.5 lakhs/unit.

Upgrading nursery infrastructure to meet accreditation norms

Nurseries in the public and private sector can avail assistance to upgrade nursery infrastructure to meet accredited norms. Rs. 10 lakhs is provided to nurseries in the public sector and 50% of the cost (Rs. 5 lakhs) is provided to the nurseries in the private sector for upgradation. The infrastructure facilities will include establishment of hot bed sterilization of media, working shed, virus indexing facility, hardening chamber/ net house, mist chamber, establishment of mother block, irrigation and fertigation facility/unit.

Seed production for vegetables and spices

Estimated cost of seed production for vegetables and spices (seed spices and chillies) is Rs. 35000/ha for open pollinated crops and Rs. 1.5 lakhs per ha for hybrid seeds. Assistance is provided @100% of total cost to public sector. In the case of private sector, assistance is 50% of cost as back-ended subsidy. Assistance is available for a maximum area of 5 ha per beneficiary.

Production and distribution of nucleus planting materials

Under NHM/MIDH, various State Governments have been assigned with programmes for area expansion, high yielding variety coverage, rejuvenation *etc.*, requiring sizeable quantity of quality planting materials of the respective spice crops. In order to meet the requirement of various planting materials for the above programmes, nucleus planting material production programme with all the available released high yielding varieties is being taken up directly by the Directorate of Arecanut and Spices Development, including building up the required facilities in the research farms attached to the State Agricultural Universities, ICAR institutes *etc*. All the selected spice crops under NHM programmes assigned to the State Governments are included.

Quality parameters of planting material adopted

It is important that the plant propagule attains the required growth before it is planted in the field. The standards for planting material of different spice crops are given below:

Table 5. Standards for planting material

Sl. No.	Crop	Standards for planting material
1	Black pepper	The age of rooted cutting should be $2^1/_2$ months old (15-20 cm height) from the date of planting in the polythene bags. A minimum of five leaves should be present with vigorous growth without exhibiting any nutrient deficiency symptoms Profusely developed roots with the absence of *Phytophthora capsici*spores and nematodes/virus infection/scale/mite/thrips/mealy bugson the cuttings. Varietal purity.
2	Cardamom	The age of the suckers/seedlings must be 9-10 months at the time of distribution A minimum of 5-7 leaves and height of 60-75 cm should be present with vigorous growth Absence of katte /clump rot/kokke kandu /fungal disease or insect infested suckers Varietal purity
3	Clove	Height of seedlings should be 50 cm (9-24 months depending upon management) Absence of diseases/pests
4	Cinnamon	One year old bagged cuttings must be used for planting. Minimum height should be 25 to 30 cm. Absence of diseases/pests
5	Ginger	Seed material should be healthy and plumpy in appearance. Scales and mealy bug infestation and dry rot infection in rhizomes must be less than 1-5% Varietal purity
6	Turmeric	Seed material should be healthy and plumpy in appearance. Scales and mealy bugs infestation and dry rot infection in rhizomes must be less than 1-5% Varietal purity
7	Nutmeg (Grafts)	Vigorously growing plant with a height of -15 cm Height and condition of the union - > 15 cm, strongly united. Scion and shoot diameters at the union - > 0.6 cm and above Well developed tap root system. Absence of dieback or shot hole symptoms

Seed standards in seed spices

The prescribed permitted seed standard limits for seed spice are given in table 6.

Table 6. Seed standards for seed spices

Crop	Seed standard (%)											
	Pure seed (minimum)		Inert matter (maximum)		Seeds of other crop (maximum)		Total weed seeds (maximum)		Germination (%)		Moisture (%)	
	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS
Coriander	98	97	2	3	0.10	0.20	0.10	0.20	65	65	10	10
Cumin	95	95	5	5	0.05	0.10	0.10	0.20	65	65	8	8
Fennel	95	95	5	5	0.05	0.10	0.10	0.20	70	70	8	8
Fenugreek	98	98	2	2	0.10	0.20	0.10	0.20	70	70	8	8
Ajwain	95	95	5	5	0.05	0.10	0.10	0.20	65	65	8	8
Dill	95	95	5	5	0.05	0.10	0.10	0.20	70	70	8	8

FS - Foundation Seed; **CS -** Certified Seed
Note: Insect damaged seeds should not be more than 0.5% in each sample.

Adoption of good nursery management practices

The three most important aspects in planting material production are:

1. Making available improved varieties of spices released in sufficient extent
2. Adoption of appropriate propagation techniques
3. Technology for making available quality disease-free planting materials

Making available improved varieties of spices released by Research Stations in sufficient quantity

a) Prominent high yieldingvarieties of spices available in the country

Our country is fortunate to have wide genetic variability for exploitation in crop improvement. As a result a number of improved varieties have been released from Indian Council of Agricultural Research Institutes, under the All India Coordinated Research Projects (AICRP) on Spices and SAUs. So far more than 250 improved varieties of spices have been developed in our country. However, the coverage of high yielding varieties in spice sector needs to be improved considerably. In the absence of adequate programmes for popularization and large scale multiplication of these improved varieties/cultivars, their cultivation is still confined to the upper strata of the farming community and yet to reach the small and marginal farmers who accounts for more than 80% of the area under cultivation of these crops. Important varieties of spices are listed below:

Black pepper: Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Panniyur-6, Panniyur-7, Panniyur – 8, Subhakara, Sreekara, Karimunda, Panchami, Pournami, Kottanadan, IISR-Thevam, IISR-Shakthi, Vijay *etc*.

Ginger: Suprabha, Suruchi, Surabhi, Himagiri, IISR-Varada, IISR-Rejatha, IISR-Mahima, Maran, Rio- de-Janeiro, Himachal, Valluvanad, Kuruppampady, Aswathy, Karthika, Aathira, Nadia *etc*.

Turmeric: CO- 11983, BSR-11986, BSR-21994, Roma, Suroma, Ranga, Rasmi, Rajendra Sonia, Megha Turmeric-1, Pant Peethabh, Suranjana, Duggirala, Alleppey Supreme, Kedaram, Suvarna, Suguna, Sudarshana, Prabha, Prathibha, Kanthi, Sobha, Sona, Varna, Narendra Haldi 1 *etc.*

Chilli: K-1, K2, Co-1, , PusaJwala, PusaSadaBahar, NP 46A, Capsicum– PusaDeepti, KDC-1, Pant C-1, Pant –C2, Kalyan Sel.1, G1-1962, G2 -1962, G3-1962, BhagyaLaxmi, , LCA-305, LCA 334, LCA 235, LCA

353, Punjab Lal, CH-1, CH-2, CH-3, ArkaHarita, ArkaLohit, ArkaMeghana, Jwalasakhi, Jwalamukhi, Ujjhala, Anugraha, KA-2, HisarShakthi, Hisar Vijay

Garlic: Agrifound white, Yamina Safed-1, Yamuna Safed -2, Yamuna Safed-3, AgrifoundParvati, G-323, Pant Lohit-1, Pant Lohit-2, Pusa Sel-10, HG-1, HG-6.

Cinnamon: IISR-Nithyasree, IISR-Navasree, YCD-1, PPI(C)1, Konkan Tej, Sugandhini, RRL (B), *etc.*

Nutmeg: Konkan Sugandha, Konkan Swad, Viswashree

Tamarind: PKM-1, DTS-1, Prathisthan, NO.263, Yogeswari

Curry leaf: DWA-1, DWA-2, Suvasini

Coriander: Guj.Cor.1, Guj.Cor.2, Co.1, Co.2, Co.3, Rajendra Swati, RCr.41, RCr.20, RCr.435, RCr.436, RCr.446, Sadhana, Swathi, Hisar Sugandh, HisarAnand, Pant Haritima, Azad Dhania–1 *etc*.

Cumin: MC 43, Guj. Cumin 1, Guj. Cumin 2, Guj. Cumin-3, Guj. Cumin-4, RZ 19, RZ-209, RZ-223*etc*.

Fennel: Guj. Fennel 1, Guj. Fennel-2, Co-1, RF-101, RF-125, HisarSwarup, Azad Sauf-1, Pant Madhurika, Rajendra Sourabha *etc*.

Fenugreek: Co.1, Co.2, Rajendra Kanti, Rajendra Abha, Hisar Sonali, Hisar Suvarna, Hisar Guj. Neethi, RMt.1, RMt – 143, RMt-303, RMt-305, Rajendra Khushba, Pusa early bunching

Ajwain: Gujarat Ajowan-1, Pant Ruchika, RPA-68, Ajmer Ajowan-1, Ajmer Ajowan-2, Lamsel-1, Lamsel-2, Rajendra Mani

Celery: RRL-85-1

Dill: Guj. Dill-1, Guj. Dill-2, RSP-11, Ajmer Dill -1, Ajmer Dill-11

Adoption of appropriate propagation techniques

Shortage of quality planting material is the major bottle-neck in the production of spices.There is immense scope in the employment and income generation through production and supply of quality planting material of spices.But lack of awareness and technical know-how for production of quality planting material hampers spice production. So, farmers need to adopt appropriate production techniques for planting material production.

In the case of black pepper, serpentine method,raising of shoots on inclined bamboo stick are popular in planting material production. Pro-traytechnique in ginger and turmeric is being popularized for the production of healthy planting material. Different types of vegetative propagation methods are recommended for tree spices.

Table 7. Propagation techniques

Sl. No.	Spice	Propagation Techniques
1	Black pepper	*In situ* planting, raising of rooted cuttings in poly bags, rapid multiplication method or bamboo method, serpentine method
2	Ginger and turmeric	Pro-traytechnique, rhizome propagation
3	Chilli	Raising of seedlings
4	Nutmeg	Seed propagation, epicotyl grafting and budding
5	Cinnamon	Seed propagation, cuttings and air layering
6	Clove	Raising of seedlings
7	Garlic	Cloves or bulbils
8	Seed spices	Raising of seedlings

Technology for making available quality disease-free planting materials

Production of healthy (disease-free) planting material of spice crops becomes a crucial issue in ensuring longevity, productivity and sustainability of the crop over years. This is mainly because there are several soil-borne pathogens that become a major production constraints in these crops. Being soil-borne, these are more elusive for an effective disease management. Over and above, many of the spice crops (baring seed spices) are vegetatively propagated and vertical transmission of the disease becomes important and hence, ensuring seed health/plant health is of paramount importance.

Table 8. The following are the major soil-borne diseases of spice crops

Black pepper	*Phytophthora capsici* - foot rot *Radopholus similis* *Meloidogyne incognita* } slow decline
Cardamom	*P. meadii- Capsule rot* *Fusarium oxysporum* - } root rot *Meloidogyne incognita* *P. vexans* *Rhizoctonia solanidamping off / clump rot*
Ginger	*Pythium aphanidermatum*/ P.*myriotylum* - soft rot *Ralstonia solanacearum* - bacterial wilt *Fusarium oxysporum*f.sp. *zingiberi* - yellows *Pratylenchus coffeae* *Meloidogyne incognita* } nematodes
Turmeric	*Pythium graminicolum/ P.aphanidermatum* *Fusarium solani* *Pratylenchus coffeae*
Vanilla	*Fusarium oxysporum*, *Phytophthora meadii*
Cumin	*Fusarium oxysporum* f.sp. *cumini* - wilt
Coriander	*Fusarium oxysporum* f.sp. *corrianderi* – wilt
Fenugreek	*Rhizoctonia solani* – root rot

Many of the above soil borne plant pathogens are known to be seed-borne/ plant-borne which go unnoticed as they look apparently normal at nursery stage/early stage of crop growth. It is here the sanitization of planting material becomes important to ensure disease-free planting material. Supply of disease-free nursery stock becomes an essential pre-requisite for the developmental agencies to further multiply the nucleus planting material provided by the R & D institutions (SAUs/ICAR). Besides, the appraisal of the farming community about the status of disease problems and the quality of planting material are important to make the healthy planting material production programme a success.

Strategies for healthy planting material in spices

In the absence of high degree of host resistance for many of the soil-borne plant pathogens, it becomes imperative to give a major thrust on an effective disease management which starts right from nursery stage. Over years, the microbial technology suppressive to soil-borne plant pathogens in spices have been developed which becomes handy to implement. These microbials need to be exploited to ensure protection from root infection.

a) Soil disinfection of the nursery mixture

Soil disinfection through fumigants or through complete soil sterilization becomes difficult because of high energy costs involved. However, soil solarisation technique developed by Israel is important and practicable. The nursery mixture solarised becomes an effective medium to reduce the chances of soil borne pathogens and consequent infections.

b) Incorporation of bio-control inoculums into the nursery mixture

Soil solarisation combined with microbial inoculum which was found as effective disease suppressers is a proposition to reduce root infections in the nursery programmes. Of the microbials available vesicular arbuscular mycorrhiza (VAM), antagonist like *Trichoderma* spp., *Psuedomonas* spp., *Bacillus* spp. have been extensively used for the nursery programmes as well as field management of the disease. *Glomus fasiculatum* is one VAM fungus which has been extensively investigated and was found effective in protecting the root system against *Phytophthora capsici, Radopholus similis* and *Meloidogyne incognita*. Incorporation of VAM inoculum into the nursery mixture (either solarized or nonsolarized) prior to planting would ensure greater protection of the root system, leading to production of disease-free planting material.

c) Fungal antagonists / hyperparasites

Fungal antagonists like, *Trichoderma harzianum*and*Trichoderma viride* have been amply demonstrated to be highly effective in checking the soil-borne infections. This has been well established for control of soil-borne pathogens in the case of black pepper, cardamom, ginger, turmeric, cumin, coriander and fenugreek. As such, it is recommended to incorporate these bio- inoculants into the nursery mixture.

Similarly, *Psuedomonas fluorescens*, *Bacillus subtilis* and Plant Growth Promoting Rhizobacteria (PGPR) are the other important bacterial antagonists which are found effective against soil-borne problems. These also can be incorporated into the nursery mixture. These PGPRs not only ensure protection from the soil-borne pathogens but also ensure plant growth and induced systemic resistance that would ensure health of the planting material.

d) Seed disinfection

In the case of black pepper, mother vines should be selected only from a uniformly established gardens free from diseases and pest. These selected vines should be monitored at least once in a year for a possible infection of the disease and continuously monitored for future use.

In the case of ginger and turmeric, the soil-borne plant pathogens *viz*., *Ralstonia solanacearum*, *Pythium aphanidermatum*, *Pratylenchus coffeae* thatremain associated with the planting material when the seed rhizomes are collected from diseased gardens which are apparently normal. Collecting normal rhizomes from the field is age old practice of farmer without giving due importance to source (healthy plot and diseased plot). These apparently normal rhizomes when used for fresh planting become source of initial infection in the field and subsequent spread. It is important to eliminate these seed-borne pathogens from the rhizomes and followed by seed treatment with some of the above mentioned microbial bio-inoculants (biocontrol agents). In Sikkim, seed treatment of ginger seed rhizomes at 51^{o}C for 10 minutes was found to be highly effective in seed disinfection which resulted in a better crop free from dry rot (*Pratylenchus-Fusarium-* complex). When hot water treated rhizomes are coated with biocontrol agents, the protection was more evident and is now being practiced in the ginger programmes in Sikkim as a part of participatory technology development (PTD) programmes. The same type of procedure can be followed for turmeric also. *F. oxysporum* being the causal agent of vascular wilt of vanilla, similar studies are warranted to eliminate inoculum in symptomless stems.

e) Virus diagnostics

CMV and PYoMV are the important two viruses of black pepper which are prevalent in almost all the pepper growing tracks in India as well as other countries. Though they are not "killers", they affect the growth and the yield resulting in gradual decline of the affected vines. These viruses being systemic in nature, it is important that the planting materials are ensured free from these two viruses. The disease-free mother vines should be properly identified through diagnostic criteria (PCR or ELISA based) as totally disease free. Such planting material free from these two viruses should be released to the developmental agencies as nucleus planting material for further multiplication. The virus diagnostics are very important since apparently normal/symptom less pepper vines have been observed in the field sourcing planting material from such apparently normal vines will result in disease spread and hence, the importance of virus diagnostics. The same methodology need to be adopted in the case of vanilla, small cardamom and ginger where viruses are associated with planting material.

f) Micropropagation (tissue culture) as a strategy for production of healthy planting material

Biotechnological method of plant propagation called as micropropagation through tissue culture technique is in vogue for several horticulture crops. Protocols for micropropagation of spices have been standardized. The biggest advantage of tissue cultured black pepper cuttings is total elimination of all the major pathogens, if one selects explants from high yielding mother vines totally free from virus diseases (CMV and PYMoV), which otherwise is impossible in conventional multiplication through vegetative propagation mentioned earlier. Low rate of multiplication 1:10 approximately, highly sophisticated infrastructure and high cost of production are the limitations of this method. However, this approach becomes imperative if production of healthy planting material becomes impractical through conventional methods.

The biggest constraint identified in planting material production of ginger is the prevalence of diseases like soft rot diseases (both fungal and bacterial), *Bellakettu*disease and pests like shoot borer rhizome maggot *etc*. Soft rot of ginger is very rampant and is one reason due to which farmers hesitate to take up the cultivation in large scale. Production of disease-free planting material in ginger can reduce the risk of total crop loss and the period of rotation of the crop in the field. The micro-tuber production technology in ginger can ensure 100% elimination of pathogen from the seed material. This technology is successful with ginger and is being tried for commercial application.

The micro and mini rhizomes so raised in the labs can be grown and multiplied under protected condition in polyhouses in soil-less culture medium to ensure that the seed rhizome continues to be disease free. However, the cultural practices for polyhouse cultivation need to be fine tuned for ginger crop.

Conclusion

National Horticulture Mission had originally aimed at doubling the production of horticulture crops by the XI Plan period, primarily through improvement in productivity of the crops. To achieve this task, availability of healthy planting materials of improved varieties takes the center stage of all developmental activities. As per the reports available from NHM/MIDH, around 2939nurseries including small, model and hi-tech nurseries under public/private sector have been set up across the country under NHM. The Directorate of Arecanut and Spices Development has been supplementing these efforts by implementing programmes on nucleus planting materials through various StateAgriculturalUniversities and National Research Institutes. Thus, there is a concerted effort from the Government of India to improve upon the availability of the quality planting materials of high yielding varieties in spices, which will pave the way for the development of spice industry in the country in a sustainable way.

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Quality seed production in seed spices - Issues and strategies

Dhirendra Singh*, D K Gothwal & A C Shivran

ICAR-All India Coordinated Research Project on Spices
SKN College of Agriculture, SKNAU, Jobner-303329, Jaipur, Rajasthan
*dhirendrasinghjobner@gmail.com

India is known as the 'Land of spices' as foreign invaders invaded India for spices in ancient times. Vasco De Gama discovered sea route to India only for spices trade. India is the largest producer, consumer and exporter of spices and spice products. It produces a wide variety of spices. Main seed spices of India are coriander, cumin, fennel and fenugreek. There is good potential for increase in production and export of seed spices, if quality is improved.

Every farmer should able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage. Timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers. The seed plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties.

Good quality seeds refer to seeds having optimum genetic and physical purity, high germination procedure percentage and seed with optimum moisture content. It also includes seeds free from noxious weed seed and other crop seeds and free from seed borne diseases. To meet these criteria there is a need of certification.

Quality seed production which follows efficient certification procedures plays a major role in the increase of food production of our country. To ensure this, the Government has prescribed standards and has brought in seed production techniques, testing, certification and marketing procedures through the Seeds Act, 1966. In the current scenario, the demand for good quality certified seeds far exceed the availability in the market.

The rapid development of agricultural production necessitated the enactment of seed legislation. The basic purpose of seed legislation and its subsequent enforcement is to regulate the quality of seed sold to farmers.

The Seeds Act passed by the Indian parliament in 1966 created a climate, which could make good quality seeds available to the cultivators. Seed Rules under the Act were framed and notified in September 1968 and the Act was implemented in its entirety in October 1969. It is applicable only to notified kinds/varieties of seed and vegetatively propagating materials used for sowing. Even though the concept of Seed certification was known in India, the enforcement of provisions of Seeds Act in the year 1969, gave beginning to the systematic arrangements for large scale seed certification. The Act provides for the formation of an apex advisory body, namely, the Central Seed Committee; the Central Seed Certification Board; establishment of Seed Certification Agencies; and Central and State seed testing laboratories, *etc*. The Act provides for the provisions for notification of kinds/varieties to be brought under the purview of the Seeds Act; regulation regarding the sale of seed; and the establishment of a suitable seed law enforcement machinery. Under the Act the Central Govt. is empowered to make rules to carry out the purposes of the Act and to give directions to State Govt. It is necessary, for carrying into execution, in the state concerned the provisions of the Act or Rules. Seed Certification Agencies function in accordance with The Seeds Act 1966 (section 8).

An assured supply of genetically pure seeds of a variety at reasonable cost is one of the most important links in its dissemination and adoption. Obviously every successful crop improvement project must be supported by a sound seed production programme so that exploitation of the potential of a good variety is not withheld because of poor seed supply or impurity of the seed.

Genetic purity

Genetic purity means plants and seeds confirming to the characteristics of the variety as described by the breeder. Over the years, this purity is lessened in a variety due to reasons like mutations, mechanical mixture *etc*. One basic aim is to produce seed which is genetically pure to the set standards. Hence, it is essential to control the factors which will deteriorate genetic purity. Let us look at such factors which influence the seed production.

Genetic principle

Deterioration of varieties

Genetic purity (trueness to type) of a variety can be deteriorated due to several factors during production cycles. The important factors of apparent and real deterioration of varieties are as follows:

a) Developmental variation

When the seed crops are grown in different environment, under different soil and fertility conditions, or different climate conditions, or under different photoperiods, or at different elevation for several consecutive generations, the developmental variation may arise some times as differential growth response. To minimize the opportunity for such shifts to occur in varieties it is advisable to grow them in their areas of adaptation and growing seasons.

b) Mechanical mixtures

This is the most important source of variety deterioration during seed production. Mechanical mixtures may often take place at the time of sowing, if more than one variety is sown with same seed drill; through volunteer plants of the same crop in the seed field; or through different varieties grown in adjacent fields. Often the seed produce of all the varieties are kept on same threshing floor, resulting in considerable varietal mixture. To avoid this sort of mechanical contamination it would be necessary to rogue the seed fields and practice the utmost care during seed production, harvesting, threshing and further handling

c) Mutations

This is not a serious factor of varietal deterioration. In the majority of the cases it is difficult to identify or detect minor mutation.

d) Natural crossing

In sexually propagated crops, natural crossing is another most important source of varietal deterioration due to introgression of genes from unrelated stocks which can only be solved by prevention

Natural crossing occurs due to following three reasons

- Natural crossing with undesirable types
- Natural crossing with diseased plants
- Natural crossing with off- type plants

Natural crossing occurs due to following factors

- The breeding system of species
- Isolation systems
- Varietal mass
- Pollinating agent

e) Minor genetic variations

Minor genetic variations may exist even in the varieties appearing phenotypically uniform and homogeneous at the time of their release. During later production cycle some of this variation may be lost because of selective elimination by the environment. To overcome these yields trials are suggested.

f) Selective influence of diseases

The selective influence of diseases in varietal deterioration is also of considerable importance. New crop varieties often become susceptible to new races of diseases often caused by obligate parasites and are out of seed programmes. Similarly, the vegetatively propagated stocks deteriorate fast if infected by viral, fungal and bacterial diseases. During seed production it is, therefore, very important to produce disease free seeds/stocks.

g) Techniques of plant breeders

In certain instances, serious instabilities may occur in varieties due to cytogenetical irregularities not properly assessed in the new varieties prior to their release. Other factors, such as break down in male sterility, certain environmental conditions and other heritable variations may considerably lower the genetic purity.

Maintenance of genetic purity during seed production

The various steps suggested), to maintain varietal purity, are as follows.

- Use of approved seed only in seed multiplication
- Inspection and approval of fields prior to planting
- Field inspection and approval of growing crops at critical stages for verification of genetic purity, detection of mixtures, weeds and for freedom from noxious weeds and seed borne diseases *etc*.
- Sampling and sealing of cleaned lots
- Growing of samples of potentially approved stocks for comparison with authentic stocks

The various steps suggested for maintaining genetic purity are as follows:

- Providing adequate isolation to prevent contamination by natural crossing or mechanical mixtures
- Rouging of seed fields prior to the stage at which they could contaminate the seed crop
- Periodic testing of varieties for genetic purity
- Avoiding genetic shifts by growing crops in areas in their adaptation only

- Certification of seed crops to maintain genetic purity and quality of seed
- Adopting the generation system

In most cases the seed production programmes are, though inspected by a breeder or team of breeders, are carried out by the farm management officers or others not having adequate expertise in the discipline of genetics and plant breeding. For such persons an easily understandable and clearly chalked out procedure of seed production for each type of crop (cross or self) and category of seeds (breeder, foundation and certified) must be made available for successful execution of seed production programmes. It is endeavored here to delineate such a procedure for production of different categories of seeds of seed spices crops namely fenugreek, cumin, coriander and fennel.

Breeder seed production

Breeder seed forms the source seed for other categories of the seed, *viz*., foundation and certified seeds. Therefore, to maintain the acceptable level of purity of seeds of these categories it is necessary that a high level of purity is maintained for the breeder seed stock. Breeder seed is, thus a purest stock of seed and is produced under the direct supervision of the breeder of the crop. The genetic purity (referred to as purity) of breeder seed stock of a pure-line variety (as in case of fenugreek) refers to the condition that all seeds have the same homozygous genotypes and there is no seed to seed difference in the stock. While in the case of cross pollinated crops *viz*. cumin, coriander and fennel, where the varieties are genetically improved "Populations", this refers to the condition that genotype of seed stock is such that the plants of the crop produced by this lot will clearly conform to the characteristics of the variety and no plant will fall away from the limits of the varietal characteristics. Obviously in case of cross pollinated crops emphasis is given on the genetic constitution of the population rather than on the individual plant. In such crops the method of seed production should ensure that genetic structure of the improved variety is truly reproduced. To achieve this safely some guiding principles for each crop are given here.

Breeder seed production in seed spices

Fenugreek

First season

- Select the field suitable for fenugreek cultivation and required isolation.
- Sow the source seed/ nucleus seed giving adequate between row and between plant spacing, so that individual plants can be easily accessed.
- Follow agronomic and plant protection practices properly. At maturity select a number of individual plants, thresh them separately and keep in different seed packets. The number of plants selected depends purely on the required seed.

Second season

- Steps 1 to 3 same as for season I.
- Sow individual plant-progenies in breeder seed block.
- Inspect the individual progenies from the beginning of the crop and discard any progeny or progenies which show variation, not matching with the variety.
- Ensure that only the lines which truly match the variety are allowed to mature. Harvest them together, thresh and clean the seeds. Before harvesting individual plants are again taken from the selected progenies to repeat the cycle.

- Take all precautions in harvesting, threshing and cleaning the seeds so that seed quality is maintained. The seed so produced is the breeder seed which may be used as a source of foundation seed.

Cumin, coriander and fennel

First season

In principle the same steps are followed in these crops also as in fenugreek excepting the number of plants selected for next season's sowing of individual plant progenies. Here at least 1000 plants should be selected, so that even after rejection of lines sufficient number is left for inter mating so that inbreeding chances are avoided and true population structure is reproduced.

Second season

- Steps 1 to 3 are the same as in fenugreek. Of course, the requirement of isolation distances is different for different crops (see field and seed standards).
- Sow individual plant progenies in the breeder seed block having adequate isolation and as far as possible a square shape.
- Inspect the individual progenies from the beginning at regular intervals, identify the lines throwing segregants and remove them from the field. Efforts should be made to identify such lines before flowering so that off types are not allowed to contribute pollens. Harvest the selected lines together-after at least 1000 individual plants have been taken for next season's sowing of breeder seed block.
- Care must be exercised in threshing and cleaning the seed so that their quality conforms to the seed standards.
- Breeder seed so produced may be used for raising foundation seed crop.

Foundation and certified seed production

Foundation and certified seed crops are raised following approved agronomic and plant protection techniques. All care is taken to ensure that field and seed standards conform to the ones approved for the crop. Obviously timely rouging of off-types, control of diseases and pests, careful harvesting (cumin crop must be harvested only by cutting the plants), threshing cleaning and storage of seed be practices.

Seed certification

Seed certification is a legally sanctioned system to maintain quality of seeds during seed production, post-harvest operation and distribution of seeds . It includes field inspection, seed quality tests and pre and post control check.Agencies (State Governments or autonomous bodies), which are notified under Section 8 of the Seeds Act are authorized for certification of seeds. Anybody willing to come forward to produce certified seed can produce certified seed.

In India the field evaluation of the seed crop and its certification started with the establishment of National Seeds Corporation in 1963. A legal status was given to seed certification with the enactment of first Indian Seed Act in the year 1966 and formulation of Seed Rules in 1968. The Seed Act of 1966 provided the required impetus for the establishment of official Seed Certification Agencies by the States. Maharashtra was the first State to establish an official Seed Certifications Agency during 1970 as a part of the Department of Agriculture, whereas Karnataka was the first state to establish the Seed Certification Agency as an autonomous body during 1974.

At present, State Seeds Corporations, National Seeds Corporation, State Farm Corporation of India, State Departments of Agriculture, Private Companies, Cooperatives and individual farmers are producing certified seed. Producing high quality seeds of the crop varieties that are notified by the Central and State Governments and make them available to the farmers is the prime aim of the seed certification authority

Seed of only those varieties which are notified U/S 5 of the Seeds Act, 1966 shall be eligible for certification. Seeds which are certified by the Seed Certification Agency are called certified seeds, which passes through both the field and seed standards as specified by the certification body. Seed standards are specified and uniform throughout the country, whereas the seed certification procedures and fee vary from one state to another state.

Seed certification consists of the following control measures:

- It is an administrative check on the origin of propagating material for the purpose of trueness to purity (genetic purity).
- Field inspection: At the time of growing a crop for seed production purpose, the data should be obtained on trueness to varietals purity, isolation of seed crop to prevent crops- pollination, mechanical admixtures and diseases dissemination, objectionable weeds and admixtures.
- Supervision on agricultural operations *i.e.* intercultural operations, harvesting, storage, transport and processing *etc*. with a view to preserving the identity and quality of the lots.
- Sample inspection: For quality and to maintain genetic purity, a lab test of representative samples drawn by the S.C.A. for determining, % of germination, moisture content, weed seed content, admixture and purity.
- Bulk inspection: For checking homogeneity of the bulk as compared with the sample inspected.
- Control plot testing: Samples drawn both from the source seed and the final seed produced can be grown in the field along with standard samples of the variety in question. By comparison, it can be determined whether the varietal purity and health of the produced seed are equal to results based on inspection.

The purpose of seed certification is to maintain and make available high quality seed and propagating materials of notified plant varieties.

Phases of seed certification

Seed certification has five phases

- Verification of seed source
- Inspection of seed crop in the field
- Supervision at post-harvest stages including processing and packing
- Seed sampling and analysis
- Grant of certificate, certification tag, tables and sealing

Concepts of seed certification

The Association of Official Seed Certifying Agencies (AOSCA) have given some fundamental concepts of seed certification & these are:

- Pedigree of all certified crops must be essential
- The integrity of certified seed growers must be recognized
- Field inspection must be made by through qualified field inspectors
- Verification trials to establish and maintain satisfactory pedigree of seed stock
- For keeping proper records to establish and maintain satisfactory pedigree of seed stock

- Standard should be maintained for purity and germination
- The principles of sealing seeds to protect both grower and purchase must be approved

Steps required for organizing seed certification

The various steps required for organizing seed certification are:

- Establishment and operation of seed certification agency
- Establishment of minimum seed certification standards
- Establishment of procedure for field inspection, seed processing, seed sampling and testing, tagging and sealing *etc*.

The process of seed certification is initiated by an application by the seed grower for certifying the seed produced by him. These applications are made on a prescribed proforma available from the concerned SSCA and provide details about the location of farm, area of the seed plot, crop variety and the class of seed proposed to be produced, isolation *etc*. generally, the application is made well in advance of sowing of the seed crop, but in some cases it may be submitted even after the sowing. The SSCA scrutinizes such applications and on being satisfied, carries out field inspections and seed tests to ascertain the suitability of seed crops/seed lots for certification. If a seed crop/seed lot satisfies the prescribed purity and quality requirements, SSCA issues suitable tags of certification for affixing them to the seed bags under certification.

The decisions regarding the suitability of seeds for certification are based on the following inspections/operations:

- Field inspections
- Inspection during seed processing
- Seed tests (generally conducted on processed seed)

Minimum seed certification standards

In a seed quality control programme through seed certification, the minimum seed certification standards, in fact, are the minimum standard conditions which must be met. The minimum seed certification standards thus are the standards required for the certification of seeds by the certification agencies.

The certification standards in force in India are called the 'Indian Minimum Seed Certification Standards'. These were published by the Central Seed Certification Board. As a general principle, these standards have been kept at the level, which demand scrupulous attention of the certified seed growers but at the same time practical enough that these can be met also. The minimum seed certification standards can be broadly grouped into two groups.

A. General seed certification standards
B. Specific crop standards

The two combined sets of standards constitute the minimum seed certification standards for seed certification.

A. General seed certification standards

The general seed certification standard aims at outlining the general requirements for the production of genetically pure good quality seed. These standards prescribed the procedure for certified seed production so that maximum genetic purity and good quality of the seed this ensured.

B. Specific crop standards

Specific crop standard consists of field standards and seed standards.

Field standards consist of: -

- The minimum preceding crop requirements have been specified to minimize genetic contamination from the disease, volunteer plants.
- The minimum isolation requirement has been specified to minimize seed born disease contamination.
- The number of feed inflection and specified stage of crop have been described to ensure verification of genetic purity and other quality factors.

Seed standard consists of:

- The minimum percentage of pure seeds and maximum permissible limits for inert matter, other crop seeds have been prescribed.
- The maximum permissible limits for objectionable weeds, seeds infected by seed borne diseases have been prescribed to ensure goods seed health.
- The maximum permissible limits for moisture content have been prescribed for the safe storage of seeds.

Crop and seed standard for seed spices

- **Application and amplication of general seed certification standard.**
  The general seed certification standards are basic and together with the following specific standards constitute the standards for certification of the seeds of open pollinated varieties/composites in case of cumin, coriander and fennel and pure lines in case of fenugreek.

- **Land requirements**
  Land to be used for seed production should be free from volunteer plants and in case of cumin; crop rotation of three years is required.

- **Field inspection**

Cumin, coriander and fennel

Open pollinated varieties and composites

- The first inspection shall be made before flowering preferably within 45 days of planting to determine isolation, volunteer plants off types and other relevant factors.
- The second inspection shall be made during 50% flowering to check the isolation, offtypes and other relevant factors.
- The third inspection shall be made at maturity and prior to harvesting to verify the true nature of plant and other relevant factors.

A minimum of three inspections shall be made as follows:

Fenugreek

A minimum of two inspections shall be made, first before flowering and the second at the flowering and fruit stage.

1) Field standards

a) General requirements

Isolation

Seed fields shall be isolated from the contaminants shown in column 1 of the table below by the distance specified columns 2 and 3 of the said Table.

Contaminants	Minimum distance (meter)							
	Cumin		Coriander		Fennel		Fenugreek	
	Foundation	Certified	Foundation	Certified	Foundation	Certified	Foundation	Certified
Field of other varieties	800*	400**	200	100	200	100	10	5
Field of same variety not conforming to varietal purity	800*	400**	200	100	200	100	10	5
Specific requirements								
Offtype plants	0.10%	0.50%	0.1%	0.5%	0.10%	0.50%	0.10%	0.20%
Objectionable weed plants	0.05%	0.10%	None	None	None	0.05%	0.010%	0.020 %

*originally it was 100 m; **originally it was 50 m

Objectionable weeds

Fenugreek: *Melilotus spp*. (Senji)
Cumin: *Plantago pumila* (Zeeri)
Fennel: *Cuscuta species* (Dodder)
Coriander: *Lathyrus*

2) Seed Standards

a) Specific requirements

***Cumin*:**

Factor	Standards for each class	
	Foundation	Certified
Pure seed (minimum)	97.0%	97.0%
Inert matter (maximum)	3.0%	3.0%

Other crop seed (maximum)	10/kg	20/kg
Weed seeds (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	5/kg	10/kg
Germination (minimum)	65%	65%
Moisture (maximum)	10%	10%
For vapour proof container (maximum)	8%	8%

***Coriander*:**

Factor	**Standard for each class**	
	Foundation	**Certified**
Pure seed (minimum)	97.0%	97.0%
Inert matter (maximum)	3.0%	3.0%
Other crop seed (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	None	None
Germination (minimum)	65%	65%
Moisture (maximum)	10%	10%
For vapour proof container (maximum)	8%	8%

***Fennel*:**

Factor	**Standard for each class**	
	Foundation	**Certified**
Pure seed (minimum)	97.0%	97.0%
Inert matter (maximum)	3.0%	3.0%
Other crop seeds (maximum)	10/kg	20/kg
Weed seeds (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	5/kg	10/kg
Germination (minimum)	65%	65%
Moisture (maximum)	10%	10%
For vapour proof container (maximum)	8%	8%

***Fenugreek*:**

Factor	**Standard for each class**	
	Foundation	**Certified**
Pure seed (minimum)	98.0%	97.0%
Inert matter (maximum)	2.0%	3.0%
Other crop seed (maximum)	10/kg	20/kg
Total weed seeds (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	2/kg	5/kg
Other distinguishable varieties (maximum)	10/kg	20/kg
Germination including hard seeds (minimum)	70%	70%
Moisture (maximum)	8.0%	8.0%
For vapour proof container (maximum)	6.0%	6.0%

Oral Presentations

O6

Perspectives on quality planting material production (QPMP) in black pepper

K Kandiannan*, C K Thankamani & D Prasath

ICAR- Indian Institute of Spices Research, Kozhikode-673012, Kerala
*kandiannan@spices.res.in

Black pepper is propagated through seed and vegetative cuttings. Due to genetic segregation, seed is not preferred for commercial multiplication and only vegetative cuttings are used. Black pepper has two type of shoots, erect growing ‘orthotropic shoot’ and horizontal branching fruit bearing lateral shoots called ‘plagiotropic shoot’, besides runners creeping on the ground. Traditionally, vegetative cuttings having two or three nodes with one feet length made from runners collected from yielding vines are used for large-scale planting. Cuttings of plagiotropic origin will give only bush type plant, hence, are not used for field planting; however, it can be grown in pot or in home gardens.

The runners collected from field are not sufficient to produce required number of cuttings for establishing large plantations or replanting programmes. In order to meet such demand, a well structured nursery is essential. Two type of nurseries are employed *i.e.*, (i) temporary or seasonal nurseries and (ii) permanent nurseries. The nursery structure may vary from simple to hi-tech, based on need, affordability and organization. Method adopted for black pepper multiplication is also varying based on expertise and facility. Whatever may be the method of making cuttings, the runners or base material for multiplication has to be collected from disease-free, continuously high yielding varieties.

In traditional method, cuttings are produced in seasonal nurseries. In the organized nurseries, any one of the method like ‘rapid multiplication’ (bamboo method), serpentine method, ‘mount method’, ‘bed method’ or ‘column method’ may be employed to produce cuttings year round. Each method has its own merits and demerits. Multiplication rate vary between 1:40 to 1:60. The best and efficient method should be with less production cost and high multiplication rate. Field planting of rooted ‘top shoot’ cuttings start bearing the fruit early and from the base.

Use of ideal potting mixture is an important component of successful nursery. Combination of soil, sand and farmyard manure/compost at 2:1:1 ratio is the traditional mixture. Several substitutions are tested and soil-less decomposed coir pith and vermicompost at 3:1 ratio is promising. Solarization or sterilization of potting mixture and fortification with biocontrol agents would eliminate pathogens. Pro-tray can be used for raising pepper cuttings and it helps in easy transport. Good nursery management and certification are essential for the production of healthy planting material of black pepper.

O7

Turmeric transplants: Production techniques for quality planting material

R Chitra* & J Suresh

AICRP on Spices, Department of Spices & Plantation Crops,
Horticultural College & Research Institute, TNAU, Coimbatore-641003, Tamil Nadu
*chitra.varadharaj@gmail.com

Turmeric (*Curcumalonga)* is basically a tropical crop grown in India which occupies the third position in its importance among spice crops and native to tropical South East Asia. The economic part of turmeric is the dried rhizome. India has 185.32 lakh hectares under turmeric cultivation with a total production of 701.66 lakh tonnes. Turmeric is a sterile triploid plant that is vegetatively propagated by means of underground rhizomes. The rate of rhizome multiplication is very low (only six – ten times) with yield ranging from 15 to 25 tonnes/hectare. About 10-20% of rhizomes of the total yield is required for planting during the next cropping year. Maintenance of such a huge amount of seed rhizomes for annual planting is expensive and labour intensive. The conventional method of propagation has a number of drawbacks *viz*., two months dormancy period of rhizomes, only one plant can be obtained from each rhizome and a sizeable percentage of the produce has to be put aside as seed material. To overcome these problems and to produce good quality planting material with reduced cost, rapid multiplication of turmeric through single bud rhizome technology has been standardized at Horticulture College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Single bud rhizome of turmeric has been used as planting material as a cost effective technology of turmeric planting. In this method, single bud rhizome is utilized to produce transplant in pro-tray. This one month old transplant is used as planting material for turmeric cultivation.

Due to unavailability of better quality and high yielding seed rhizomes to cater current requirements of the growers, the production of turmeric transplants through rapid multiplication technique is the only way to meet out the demand of seed rhizomes. The methodology developed will help in augmenting the turmeric cultivation with good propagating material which accounts for high success rate and also increase the farm income.

Session V

Scientist-Farmer-Industry Interface

Lead Lectures

L14

High production technology in black pepper - Challenges and farmer's perspective

S J Ankegowda* & C N Biju[1]

ICAR-Indian Institute of Spices Research, Regional Station, Appangala-571201, Karnataka
[1]ICAR-Indian Institute of Spices Research, Kozhikode-673012, Kerala
*gowda@spices.res.in

Black pepper (*Piper nigrum* L.), aptly sobriquetted as 'King of Spices' and 'Black Gold' (family *Piperaceae*), is one among the most valued and widely used spices in the world. In India, it is generally grown in southern regions *viz*., Kerala, Karnataka and Tamil Nadu and is also widening its horizon into non-traditional areas such as East and West Godavari regions of Andhra Pradesh, Andaman and Nicobar Islands and North-Eastern states. According to the International Pepper Community, global production in 2014 was 336200 MT as against 378300 MT in 2013 and during 2015, the production is projected to be 374200 MT. In India, pepper is cultivated in 201381 ha, whereas in Karnataka, it occupies 21061 ha especially as an ancillary crop in coffee and arecanut based mixed cropping systems. Pepper production in the year 2014-15 was 70000 MT as against 45000 MT in 2013 and Karnataka contributed about 16000 MT, however the actual production was 28000-30000 MT. India exported 21450 MT during 2014 valued at, Rs. 1208.42 crores. Tropical weather with modest variation in day length throughout the year favours black pepper cultivation. India, once adorned the matchless position as the leading producer and exporter of black pepper has now been relegated to lower rank and placed behind its strong competitor, Vietnam in the global arena. In India, production and productivity suffered a severe setback during past several decades owing to low productivity of plantations debilitated by improper management and ravaged by several biotic and abiotic factors. Like other crops, black pepper also suffers from highly oscillating prices, skyspiralling labour cost, non-availability and low adoption of production technologies which pose a challenge to the industry, in India and elsewhere. The challenges encountered by the industry including erratic weather pattern, stresses imposed by various biotic as well as abiotic factors, strategies to mitigate the existing as well as emerging threats and farmer's perspective are discussed.

Problems and prospects

(i) Climate change: The impact of unfriendly transformation of nature

Black pepper is adapted to humid tropic conditions requiring, adequate rainfall (2000-3000 mm) and relative humidity (60-95%) at various stages of growth. The crop tolerates a temperature regime of 10-40^{o}C with the optimum range being 23-32^{o}C.

Climate change and global warming have been surfaced as watch-words during the past several decades across the world. Unpredictable and unprecedented shifts in the existing weather pattern have posed threats to agriculture, as it directly or indirectly affects the crops/cropping systems in a particular region or over larger areas. Plant disease epiphytotics are one of the major factors which have direct impact on global agricultural productivity and unprecedented climate change will further aggravate the situation. Spices, including a wide variety of economically important herbs as well as tree species are cultivated under diverse cropping systems and varied agro-ecological zones, fostered by dynamic, unpredictable weather conditions is also no exception to this unpleasant vagary. Among the spice crops, black pepper, which shares a lion part in both production and export, has also been affected by the undesirable modification of weather pattern over decades. However, by adopting various mitigation measures especially, water conservation and its judicious use, keeping a close watch on the variation in pathogen populations, resurgence of pests and need-based formulation and execution of integrated pest and disease management modules enriched with novel technologies, would reduce the adverse impact of erratic weather to a greater extent and economic production could be achieved in a sustainable manner.

In India, blackpepper growing regions of southern states receive an average of 1500-4000 mm rainfall of which, 75% is received during June to October and remaining during November to May. This makes rainfall distribution uneven and the crop suffers due to lack of soil moisture, especially during March to May months which adversely affect nutrient absorption. This phase is critical as initiation of floral primordia occurs during this period. Low soil moisture content coupled with intense radiation and high temperature results in wilting of vines. Rainfall of 70 mm received during May-June is sufficient enough for triggering the process of flowering, however once the process initiates; there should be uninterrupted showers until fruit maturation and ripening. The delayed commencement of South-West monsoon often delays flowering and profound North-East monsoon showers after a dry spell succeeding South-West monsoon would lead to heavy spike shedding. Implications from past climate trends and its relationship with productivity indicates that, climate change in terms of increase in temperature may negatively affect black pepper productivity especially in plains whereas, increase in minimum temperature have positive influence in high elevations.

Impact of weather on biotic and abiotic stresses

Foot rot

Climatic parameters are major determinants of *Phytophthora* infection in black pepper. *Phytophthora* infection of black pepper in arecanut-black pepper mixed cropping system was positively correlated with rainfall, number of rainy days and relative humidity and was negatively correlated with temperature and sunshine hours. A daily rainfall of 15.8-23 mm, relative humidity of 81-99 %, temperature range of 22.7°C-29.6°C and sunshine hours of 2.8-3.5 per day during the peak monsoon period of the year are conducive for the maximum development and spread of the disease. The maximum disease incidence was noticed during August and was correlated positively with relative humidity and negatively with maximum temperature prevailed during the period.

Anthracnose/ fungal pollu

High rainfall and number of rainy days could be key determining factors in the outbreak of anthracnose of black pepper in the high range zones. Maximum temperature had negative correlation, while minimum temperature, rainfall and number of rainy days had positive correlation with the disease incidence. Newly emerged leaves on the runner shoots, orthotrophs (climbing/top shoots) and plagiotrophs (lateral spike bearing shoots) as well as young spikes were found to be more vulnerable to the disease.

Spike shedding

Mixed cropping of black pepper with coffee is a common practice in many coffee growing regions of India, especially in Karnataka. In hilly regions, crop failure due to foot rot, spike shedding, anthracnose and moisture stress have been reported particularly in rainfed mixed cropping system. In rainfed areas, pre-monsoon rains play the foremost role in determining productivity of the crop. One of the reasons behind spike shedding is lack of pollination (besides anthracnose/fungal pollu) due to the absence/very low frequency of either male or female flowers. Flower composition in shed spikes during the month of August indicated predominance of female flowers instead of bisexual flowers, highlighting the shift in sexual forms. Though irrigation, variety, standard, age of the vine and management were uniform, the quantum of incident light made the difference in the flower composition. In shaded condition, the drift towards female status was pronounced and spikes comprised of only 3.9% hermaphrodite flowers as against 83% hermaphrodite flowers in exposed conditions. High percentage of bisexual flowers is essential for good fruit set and this shift towards female phase leads to substantial reduction in pollination and subsequent spike shedding during July, August and September. The light availability can be enhanced by proper shade regulation of standards or shade trees during May-June for realizing higher hermaphrodite to female flower ratio. Influence of pre-monsoon rainfall pattern on black pepper setting in black pepper-coffee mixed cropping system indicated that, continuous precipitation during March, April and May had positive impact on production in Robusta and Arabia mixed cropping systems. The areas which received 250-400 mm rain during pre-monsoon period yielded better with good crop prospects indicating that, a minimum of 250-400mm rainfall during March to May is essential in shade regulated plantations for early initiation of spikes and subsequent fruit setting, followed by adequate rainfall during June for elongation of spikes.

Influence of summer irrigation during March to May months and management practices on black pepper spike production, berry setting and yield in coffee-based cropping systems indicated that, pre-monsoon irrigation has a significant positive impact on spike production and yield. The yield increase in irrigated areas was more than three-fold compared to the rainfed areas. The lower number of berries per spike in rainfed areas is due to partial setting of spikes which implies that, delayed spiking may lead to partial setting. Low spike intensity in rainfed condition is due to staggered and delayed spiking, lower bisexual flowers, higher anthracnose incidence and spike shedding. Basin irrigation of vines during March-May and shade regulation in April helps in early initiation of spikes and good setting and also to harvest fairly good crop in high altitude in coffee-based cropping system where black pepper is grown as mixed crop. Early production of spikes and new foliage followed by early maturity resulted in field tolerance to anthracnose disease and low spike shedding.

(ii) Biotic and abiotic stress: The multi-factor triggered risks

Black pepper is vulnerable to the attack of several biological entities belonging to oomycetes, fungi, viruses, nematodes and insect pests which inflict damage to the crop either singly or in combination. The weather conditions prevailing in the black pepper growing regions and the cropping systems with a broad spectrum of component crops favours the biotic entities to proliferate and inflict damage to a considerable extent, which is irreversible in most of the cases. In India, black pepper is grown as a component crop in different mixed cropping conditions withcoconut, arecanut, mango, coffee and jack trees. Mixed cropping is also practiced in Brazil, where in pepper-rubber and pepper-clove mixed cropping systems are common and extensive. Other crops inter-cropped are cocoa, papaya, orange and lemon. Themixed/intercropping system though proved to be remunerative; the possibility of pest and disease development is high. In black pepper cultivating tracts of South India, black pepper is generally grown as an ancillary crop in coffee-based cropping system (Robutsa/Arabica), where black pepper gets a second priority and hence, there is a tendency to defer many vital operations especially the plant protection measures. This has resulted in the wide spread damage caused by diseases, which often attains epiphytotic proportions in several unattended plantations.

Biotic stresses

(a) Foot rot

Foot rot incited by *Phytophthora capsici*, is the major production constraint in India and other black pepper cultivating countries. *P. capsici* infects all parts of the vines and severity of the disease depends upon the parts affected and extent of the damage. In black pepper, maximum feeder root production and emergence of new foliage occurs after the receipt of pre-monsoon showers, which is an ideal condition for proliferation of the pathogen under field conditions. When infection on feeder roots reaches the collar region through main roots, yellowing, defoliation and subsequent death of vines occur. Yellowish discolouration of the foliage becomes more pronounced after the retreat of monsoon during October-November months, as the feeder root system is damaged due to attack of the pathogen which fails to meet demand of the vines in terms of water and nutrients.

(b) Slow decline

Slow decline, otherwise known as yellows is a debilitating disease of which is a result of feeder root damage caused by nematodes *viz*., *Radopholus similis*, *Meloidogyne incognita* and the pathogen, *P. capsici* either singly or in combinations. The above ground symptoms include foliar yellowing, defoliation, reduction in the vigour and productivity, leading to slow death of vines. In general, expression of symptoms is noticed from October with foliar discolouration (yellowing), initiating from lower portion and advancing to upper parts of the vines.

With the adoption of integrated management strategies, damages inflicted by *Phytophthora* and infestation of nematodes can be reduced to a greater extent and the vines can be rejuvenated. Severely affected and dead vines harbour propagules of *P. capsici*, which serves as primary source of inoculum from which the disease spreads to adjacent vines, aided by wind and rain splashes. Hence, as a phytosanitary measure, severely affected and dead vines should be removed and destroyed. Prophylactic measures such as, spray with Bordeaux mixture (1%) and drenching basins at a radius of about 45-50 cm (active feeder root zone) with copper oxychloride (0.2%) @5-10 liters per vine during May-June and subsequent sprays and drenching during August-September and October (if monsoon prolongs) is highly essential to ward-off the disease. The use of combination fungicide, metalaxyl-mancozeb (0.125% @5-10 liters per vine) both as spray and drench after the receipt of a few monsoon showers is also recommended to rejuvenate the infected vines. Spot application of granular nematicides along with drenching the basins with copper oxychloride (0.2%) or potassium phosphonate (0.3%) twice a year during May-June and September-October helps in reducing the nematode and pathogen populations significantly. Application of neem cake @ 250-1000 g per vine during pre-monsoon and late monsoon periods also reduces nematode population. The soil can be fortified with fungal biocontrol agents like *Pochonia chlamydosporia* or *Trichoderma harzianum* @50 g per vine (or mass multiplied in appropriate substrates like compost, farmyard manure) during April-May and September-October.

(c) Viral disease

In the virus affected vines, the leaves become chlorotic, small and narrow with varying degrees of deformation, appear leathery, puckered and crinkled. The affected vines exhibit shortening of internodes to varying degrees. Severely affected vines remain stunted bearing small yellowish leaves. The symptoms are more prominent during February-May. The disease attains severity, when the vines are under stressed conditions, particularly during the summer months.Two viruses *viz*., *Cucumber mosaic virus* (CMV)and *Piper yellow mottle virus* (PYMoV)are found to be associated with the disease. The major means of spread of both the viruses are through the infected planting material used for propagation. The disease is also transmitted through insect vectors such as aphids (CMV) and mealybugs (PYMoV). As the expression of symptoms varies with seasons, virus-free plants cannot be identified solely based on symptoms. Hence, it is recommended to index the mother vines with tests such as enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) to confirm virus-free status. In nurseries, planting materials should be raised under insect-proof conditions and checked periodically for disease incidence (0.1-1% of plants, depending on the batch size of plants produced). In nurseries as well as plantations, whenever insect vectors such as aphids and mealybugs are noticed, sprays with recommended insecticides at recommended dosage may be resorted to check the population build-up.

(d) Anthracnose/ fungal pollu

Anthracnose/ fungal pollu is an economically important disease, prevalent throughout the black pepper growing tracts of India. *Colletotrichum gloeosporioides*, the incitant of anthracnose is also an important pathogen on other major spice crops. The fungus attacks all the aerial parts including foliage, stem, spikes and berries and often attains epiphytotic proportions especially in the high elevation regions where, misty conditions prevail. Irrigation of vines 4-5 times @40 to 50 litres per plant commencing from March, followed by shade regulation of support trees to provide minimum 7500 to 10000 lux light under cloudy condition (providing 40% shade) and spraying Bordeaux mixture (1%) or the combination fungicide, carbendazim-mancozeb (0.2%) or mancozeb (0.2%) the disease.

(e) Scale insects

More than 10 species of scales insects are reported to attack black pepper in nurseries as well as in the plantations of which, mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) are the major ones. Mussel scales are commonly observed as encrustations on the main stem of younger vines, lateral branches, mature leaves and berries. While, the coconut scale mainly infests leaves and is rarely observed on lateral branches and berries. In general, population of scale insects attains peak during post-monsoon or summer months. Due to infestation, the leaves develop chlorotic spots, which further results in the yellowing and drying of infected portions. Severely affected plant parts should be pruned and destroyed. Adopting spray schedules with recommended insecticides during January-February or neem-based formulations were found to be effective in reducing the infestation.

(f) Mealybugs

About nine species of mealybugs occur in black pepper of which, *Planococcus* sp., *Ferrisia virgata* and *Pseudococus longispinus* are the important ones. Mealybugs inflict damage by sucking sap from tender portions of the vines such as shoots, leaves and berries. Persistent association of mealybugs results in yellowing, wilting and mortality of younger vines and leading to gradual decline and death of older vines. Besides inflicting direct damage to the crop, *F. virgata* transmits PYMoV, one among the incitant of viral disease. The infestation is generally noticed throughout the year, which normally attains severity during post-monsoon period (from October). In nurseries, infestation of mealybugs can be checked by spraying dimethoate (0.05%) and in plantations, infestation can be managed by drenching chlorpyriphos (0.075%) at the plant basins during initial stages of infestation along with control measures adopted against *Phytophthora* and nematodes.

(g) Termites

Black pepper vines require a reliable support referred as standard for proper upward growth and development of the canopy. In India, living supports like *Erythrina indica/ E. lithosperma*, *Glyricidia* sp., *Garuga pinnata*, *Ailanthus malabarica* and *Grevillia robusta* (Silky oak) are used for trialing the vines. However, standards with dry barks are more prone to the attack of termites, especially in low rainfall regions with long spells of dry periods. Management measures need to be undertaken using recommended insecticides which may be applied @4-5 liters per standard during the month of September.

Abiotic stresses

Sun scorching

Damage due to sun scorching is more pronounced in plantations in which the vines are exposed to direct sunlight. Discolouration (yellowish leaves) and drooping are the common symptoms manifested on the affected vines. Newly planted as well as young vines are more vulnerable to sun scorching compared to the older plants. The damage can be alleviated by adopting measures like avoid planting the vines on South-West direction of the standards and protecting the young vines by covering with plated coconut fronds. Mulching basins of the vines during summer (after the cessation of North-East monsoon) with arecanut husk or dried leaves would reduce the temperature at root zone and also retains the moisture. The adverse impact of over exposure to sunlight can be overcome by spraying the vines (in the exposed areas) with 3% lime during the months of January-February and also by irrigating the vines.

Moisture stress

Poor water management strategies would adversely affect growth of the vines, subsequent decline in the yield and even could be fatal to the plants. General yellowing, drooping of the leaves and wilting are the common symptoms associated with moisture stress. Extensive damage to the feeder root system caused by pathogens and nematodes further aggravates the problem and yellowing due to moisture stress is more pronounced in the vines that are severely affected with the pathogens. The plantation should have adequate infrastructure facilities for collecting and storing water received through rain during monsoon. Construction of appropriate water harvesting/ storing structures is highly essential to cater need of the vines during summer months. Irrigating the vines at regular intervals by adopting pot/hose/drip methods is indispensable to protect the vines from this perennial problem.

Water stagnation

Stress imparted due to excessive moisture *i.e*., water stagnation is as important as the damage caused due to inadequate moisture levels. Damage due to water stagnation is generally noticed in the areas where black pepper is grown in low-lying lands. Providing adequate drainage facilities and grafting the scions of high yielding varieties on *Piper colubrinum*root stocks and growing the grafts in the low lying areas prone to water stagnation is considered as an alternative method.

Nutrient deficiency

The deficiency symptoms appear when the essential mineral nutrients become scarce in the soil continuum. Due to deficiency of nitrogen, older as well as younger leaves become chlorotic. Growth retardation and reduction in leaf size are associated symptoms. Leaf tip and margins at lower end become necrotic and brown in colour. When soils are deficient in magnesium, pale yellow discolouration develops on the leaf tips and margins. The veins on the leaves remain green and the laterals turn yellow in colour. In case of iron deficiency, interveinal chlorosis of young leaves is noticed which later turns completely yellow. Toxicity due to excess accumulation of elements in soil, such as aluminium also results in the yellowish discolouration and drooping of leaves. In order to achieve an optimum production on a sustainable basis, judicious fertilizer schedules, based on soil test analysis need to be arrived and should be strictly adhered. Location specific recommendation of nitrogen, phosphorus and potash as well as other essential nutrients for black pepper need to be followed irrespective of whether the crop is grown as a pure crop or intercrop.

Tracking and tackling the threats: Farmer's perspective

On farm trials on impact of irrigation on spike shedding

Grower's participatory trials were conducted in different zones (spanning 13 estates in Kodagu, Karnataka). The schedule with shade regulation, 4-5 round of basin irrigation, 2-3 rounds of Bordeaux mixture (1%) spray, one round of compost application, two rounds of recommended fertilizer application, liming/dolomite application once in two years, need based micronutrient application was followed in all the estates. The foliar infection of *Phytophthora* was contained by timely spraying of metalaxyl-mancozeb (0.125%). The loose setting, spike shedding, anthracnose infection and mortality and yellowing due to foot rot infection were effectively checked in all the plantations. These trials provided leads on transforming unproductive and anthracnose infected vines to productive levels.

Murugarajendra estate, Madapur, Kodagu

The estate comprises 18 ha land with both Arabica and robust coffee and black pepper as mixed crops. After the adoption of refined production technology, foot rot which appeared in five independent spots was effectively checked and anthracnose incidence was also reduced to manageable level. Yield increased from 7 tonnes to 26 tonnes with an average of 18 tonnes.

By adopting high production technology in black pepper by giving more importance to basin irrigation, pest and disease management, shade regulation and plant nutrition, it is noticed that, the yield ranged from 2.5 to 10 kg/vine based on size of the vine. In few plantations, yield ranged from 10 to 20 kg/vine with coffee as intercrop with height of standard regulated at 30-40 feet with 3-4 meter diameter crop canopy. The estate won the Best black pepper grower in India (productivity of 8-10 MT per ha) award instituted by International Pepper Community.

(iii) High Production Technologies – Pragmatic solutions

Intensive foot rot disease management strategies

Foot rot management is the point of concern in the black pepper cultivating regions across the world. The general recommendations are not adequate to prevent the introduction, secondary spread and rejuvenation of plantations. Within the affected plantations, the fresh crop census and mortality need to be analyzed. Areas may be grouped into different categories based on disease severity and specific intensive management strategies need to be formulated and implemented which are as follows:

Location	Priority	Important agro-practices
Uninfected area	Preventing introduction of disease	Moderate shade regulation to maintain staggered umbrella canopy of shade trees Prophylactic foliar spray during early and mid-monsoon period Integrated basin management measures
Infected area with less than 5% mortality	Preventing rapid secondary spread of disease	Gap filling after 1-2 years of phytosanitation Avoidance of excess shade regulation Spot drenching with copper oxychloride (0.2%) 2-3 rounds spraying with Bordeaux mixture (1%) Spot application of metalaxyl-mancozeb

		(1.25 g/litre) to check secondary spread of the pathogen
Infected area with wide spread incidence of foot rot and yellowing	• Protecting healthy vines within infected area • Prevention of secondary spread	Avoidance of excess shade regulation Two rounds drenching of all the vines with copper oxychloride (0.2%) 2-3 rounds spraying with Bordeaux mixture (1%) Spot application of metalaxyl-mancozeb (1.25 g/litre) to check secondary spread of the pathogen
Heavily infected area with more than 50% death of vines	• Protecting healthy vines with in infected area • Prevention of secondary spread • Suppression of soil-borne spread • Rejuvenation	Avoidance of excess shade regulation Replanting with 8-10 runners/rooted cuttings per standard after 1-2 years in infected spot Two round drenching of all the vines with copper oxychloride (0.2%) 2-3 rounds spraying with Bordeaux mixture (1%) Spot application of metalaxyl-mancozeb (1.25 g/litre) to check secondary spread of the pathogen

Month-wise calendar of operations in black pepper

Months	**Agro-practices**
January	Provide shade and irrigation to young vines
February	Provide shade and irrigation to young vines Preparation of potting mixture for establishing nursery Spray lime (3%) to the vines in the over exposed areas to prevent sun scorching
March	Harvesting Plan for basin irrigation (50-80 liters per vine) at 10 days interval To manage scales, spray dimethoate (2 ml/litre) or imidachlropid (0.4 ml/litre) (spot application after harvest of the crop)
April	In areas of delayed monsoon, basin irrigation @50-80 liters per vines at 10 days interval (at least 5-8 times for early initiation of spike, good setting of berries, to reduce anthracnose incidence) Shade regulation, lime application (@1 kg/vine)
May	Continue basin irrigation Shade regulation Nutrient application: 100 g urea + 100 g DAP + 150 g MOP per vine Micronutrient spray (IISR Pepper Special - 0.5%) Apply compost (10 kg), earthing up or mulching
June	Field planting of runners/top shoots or rooted cuttings Spray Bordeaux mixture (1%) as prophylactic measure Drench copper oxychloride (0.5 kg/ 200 liters) @5 liters per vine Application of granular insecticides in the root zone (@50 g/vine)
July	Provide adequate drainage (to prevent water logging at the root zone) Monitor for the incidence of foliar/root infection of *Phytophthora* in plantations Spot spraying and drenching of vines with metalaxyl mancozeb (1.25

	g/litre) to the infected and adjacent vines (repeat the spray after 10 days) Collect and destroy infected fallen leaves and spikes Spray Bordeaux mixture (1%) to all vines to avoid further spread
August	Monitor for the incidence of foliar/root infection of *Phytophthora* in plantations Plan for spraying of Bordeaux mixture (1%) in high rainfall and misty areas
September	Spray Bordeaux mixture (1%) Drench copper oxychloride (0.5 kg/200 liters) @5 liters per vine or potassium phosphonate spray and drench (600 ml/200 liters @5 liters per vine) Application of granular insecticides in the root zone (@50 g/vine) Fertilizer application (as per recommendation) Apply compost (10 kg) and 0.5 kg neem cake per vine Micronutrient spray (ICAR-IISR Pepper Special)
October	In dry zones, drench chlorpyriphos (0.07%) @4-5 liters from 90 to 100 cm tree trunk to manage termite, root grub and mealy bug infestations Earthing up and mulching
November	Spot spraying of quinalphos or dimethoate @2 ml per litre to manage scale insects
December	To heavy cropped vines, protective irrigation may be given to avoid wilting due to water stress

Conclusion

India is bestowed with ideal climatic pattern existing across varied agro-ecological zones where spices are cultivated which helps in species diversification and expansion of area. The history of spices in India has witnessed the remarkable makeover of black pepper from a mere forest produce to a major export commodity over centuries. However, the black pepper industry, which plays a pivotal role in the spice trade of India, encounters several constraints in the production chain. Among these, unprecedented shifts in weather condition could create imbalance among the existing synchronicity between various crop production and protection activities, thus leading to a substantial reduction in production and productivity. Mono cropping, drip fertigation, intensive cultivation are future needs. Moreover, unpredictable variation in both biotic and abiotic stresses over years continues to be a threat to the sustainable cultivation of black pepper. The technical knowledge to alleviate these threats is very well documented and available at the finger tips. However, it is important that, persistent and concerted efforts should be channelized in the right direction with an outlook to rejuvenate the ailing plantations and to scale-up the production and also to achieve sustainable yield levels.

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Organic production technology in seed spices

Gopal Lal

ICAR-National Research Centre on Seed Spices, Ajmer-305206, Rajasthan
glal67@yahoo.co.in

Organic farming which is gaining popularity in recent times was originally initiated around 10000 years back by ancient farmers who started cultivation depending only on natural resources. There is a brief mention of several organic practices in our ancient literatures like Rigveda, Ramayana, Mahabharata, Kautilya Arthasashthra *etc.* In fact, organic agriculture has its roots in traditional agricultural practices that evolved in countless villages and farming communities over centuries. Organic seed spice production in India is in infancy and major credit of organic spice export goes to major category of spices produced, particularly in Kerala and adjoining parts. The production of seed spices is concentrated mainly in the arid and semi-arid regions of Rajasthan, Gujarat and Madhya Pradesh. A small group of farmers in these states also have ventured into organic cultivation however, official and authentic information regarding its production, area and export is unavailable. Organic production of seed spices have not gained much momentum due to the lack of pertinent scientific information on appropriate/novel production technologies, plant protection measures and specific varieties suitable for organic production.

Importance of organic seed spices

Organic seed spice production has the following advantages:

- Organically produced seed spices are safe, nutritious and good for human health and moreover, the technology is eco-friendly
- Organic spices are highly remunerative because of higher demand in international market as the quality is comparatively superior
- In organic-based production systems, biological life in soil becomes dynamic which further helps in enhancing availability of nutrients to plants and fertility status of the soil is maintained for a longer period of time
- It is assumed that, organically produced seed spices are more resistant to pest and diseases as compared to those produced inorganically
- Organic farming practices are nature-friendly and hence, dependency on external inputs is reduced to a greater extent

Concept of organic farming

The concept of organic farming is ambiguous to many concerns. It is assumed that, traditional agriculture, sustainable agriculture, *Jaivik Krishietc,* are organic farming. It is also believed that, the use of organic manures and natural methods of plant protection instead of using synthetic fertilizers/pesticides are organic farming. The organic farming in real sense envisages comprehensive management approach to improve the health of underlying productivity of the soil (Palaniappan & Annadurai 1999). Earlier, Lampkin *et al.* (1999) mentioned that, organic agriculture is a production system which avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives. It relies on crop rotation, crop residues, animal manure, legumes, green manure, off-farm organic waste and aspects of biological pest control (Bhattacharyya 2004).

Among all the farming systems, organic farming is gaining wide attention and acceptability among the farmers, entrepreneur policy makers and agricultural scientists. Codex Alimentarius, a joint body of FAO/WHO defines organic farming as a holistic food production management system which promotes and enhances agro-ecosystem health including biodiversity, biological cycle and soil biological activity. In its simplistic form, organic agriculture may be defined as a system of diversified agriculture wherein, crop and livestocks are managed through the use of integrated technologies with preference or depend on the resources available at farm or locally.

Principles of organic farming

- Work as much as possible within a closed system and use local resources
- Maintain long-term fertility of the soils
- Reduce the use of fossil energy to minimum and maintain soil fertility by use of renewable resources
- Avoid all forms of pollution that may result from the use of chemical-based agricultural techniques
- Organize seed spice and live stock production for efficient use of resources
- Diversification of cropping system to pursue optimum production
- Adopt cropping systems including crop rotation, intercropping, mixed cropping and relay cropping
- Establishment of decentralized structures for processing, distribution and marketing

Impact of organic farming on yield of seed spices

Diversion of existing farming systems towards organic system in seed spice production has certain impact at production level. The impact on conversion to organic farming differs from situation to situation.

- Compared to intensive farming, organic farming decreases yield and the range of decrease depends on intensity of external inputs used before conversion
- In irrigated lands, adoption of organic farming usually leads to almost stable yields
- In traditional rainfed agriculture with very low external inputs, organic agriculture has resulted in significant yield increase
- Studies on other crops have shown that under drought condition, crops in organic agriculture system produce significantly higher yield over conventional farming
- Organic farming has less long term yield variability

General guidelines for organic seed spice production

The general guidelines prepared by combining the information available from various sources (mostly from Spices Board) that are in line with the principles and practices of organic cultivation for spices crops is as follows:

- A minimum area of 0.4 ha is the eligibility requirement for organic spice growers and applicant should possess a valid organic certificate issued by an international agency
- The farmers are free to convert a portion of the farm but it is advisable that, entire farm is converted to organic, truthfully and systematically
- It is essential that all the crops in the field, where organic spices are produced are also maintained using organic methods of production
- Crop rotation involving a legume in the cropping system shall be followed and crops belonging to the same family should be avoided
- Mixed farming system, integrating animal husbandry and livestock is the most ideal

- The organic farm is to be maintained as a closed ecosystem limiting the net loss of nutrients through soil wash and surface run off from the system
- In order to avoid contamination of organically cultivated plots from neighboring plots, an isolation distance of at least 25 m width is to be maintained along boundary/periphery of the conventional farm
- A minimum of two years is required as conversion period for organic cultivation. In case of cultivation in virgin lands, the conversion period can be relaxed
- Varieties cultivated should be adapted to the soil and climatic conditions and possibly be naturally resistant to pests and diseases of the region. Seeds collected from organically grown crops shall be used. In case of non-availability, initially conventional planting material shall be used
- Well rotten farmyard manure or compost @10-12 t/ha for fennel and 4-5 tonnes may be used for coriander, cumin and fenugreek as basal application
- Aphids are major problem in seed spices. Regular surveillance is necessary for effective management of aphids. Application of fish oil, rosin soap, neem seed kernel extract (3%), neem oil (50 ml/L mixed with 50 ml soap solution) and tobacco decoction (0.05%) may be practiced for control of insects. Restricted use of Bordeaux mixture (1%) for control of root rot in fenugreek, wilt in cumin and coriander, blight in fennel and cumin can be adopted. Dusting of sulphur as a restricted use can be done for control of powdery mildew

Components of organic farming

For management of nutrients, weeds, insects, pests and diseases in organic seed spice production, the major components of organic farming employed are as follows:

- ***Organic manures*****:** FYM, sheep manure, crop residues, poultry manure, oil cakes and other farm wastes, composts (coir pith compost)
- ***Green manures*****:** Sunnhemp, Dhaincha and legumes
- ***Vermicompost*****:** Biologically degradable and decomposable organic wastes are used for preparation of vermicompost (as earthworm feed)
- ***Biofertilizers*****:** Natural fertilizers containing carrier based microorganism *viz*., *Rhizobium*, *Azotobacter*, *Azospirillum*, blue-green algae, *Azolla*, Mycorrhizae and phosphobacteria
- ***Bio-plant growth promoters*****:** The decayed plant extracts are used as liquid manure for promoting plant growth (eg.*Eupatorium* and *Gliricidia*)
- ***Bio-dynamic agriculture*****:** The indigenous and biodynamic preparations such as cow horn manure, horn silica, compost preparations (BD 502-508) can be used in organic nutrition management
- ***Weed management***: Ecological, crop husbandry, mechanical, soil solarization and biological method
- ***Bioherbicide***: De-vine, Collego, bipolaris and bidophos may be used
- ***Biological agents for controlling insects*****:** Protozoa are used as biological agents for controlling the insects. Natural enemies like spiders, insects, mites, nematodes, birds, fungi, bacteria and viruses may also be employed as biological agents

Benefits of organic seed spice production

Organic agricultural practices are based on maintaining maximum harmonious relationship with the nature aiming at non-destruction of the environment. Developed nations of the world are concerned about spreading contamination of poisonous chemicals in food, feed, fodder and fibre. Naturally, organic farming system is considered as one of the means to resolve these maladies. However, the major problem in India is the poor productivity of our soils because of the low level content of the organic matter. The main benefits of organic farming are:

- Improvement in soil quality
- Healthy foods
- Low incidence of pests and diseases
- Increased crop productivity and income
- Employment opportunities

Strategy for organic production

From production point of view a strategy with following components need to be adopted as discussed:

- Production of inputs (compost, vermicompost, bio-pesticides *etc*.) as much as possible locally
- Efficient use of inputs (time, method and quantity)
- Effective integration of perennials, animals and beneficial organisms in the farming system
- Adoption of system-based production rather than crop-based
- Improvement in traditional organic system
- Continuous experimentation at farm level to understand natural production system and interactions
- Getting certification as a group effort
- Giving importance to quality production rather than quantity
- Harvesting at proper time and cleaning as well as grading at farm level

Specific technologies for organic seed spice production

The seed spices crops *viz*., coriander cumin, fennel and fenugreek produced organically have its ready market mainly in Germany Netherlands, USA and Japan. In addition to common cultural practices already standardized for seed spices crops, the general and specific guidelines available must be used for organic production. The information available on nutrient management, insect pest and disease management in seed spices are given below crop wise.

Coriander (*Coriandrum sativum* L.)

- Application of 10 to 15 tonnes vermicompost significantly increased the concentration of trace elements (Fe, Mn) in leaves and Zn content even with 5 tonnes vermicompost (Reddy *et al*. 1993)
- Good herbage yield of 6067 kg ha^{-1} with 15 t ha^{-1} of vermicompost and highest seed yield of 1,314 kg ha^{-1} was obtained with 20 t ha^{-1} of vermicompost (Vadiraj *et al*. 1998)
- The use of bioinoculants *viz*., *Azospirillum* or *Azotobacter* as seed treatment and soil treatment in combination with 5 t sheep manure ha^{-1} recorded higher seed yield under semi-arid condition (Vashishtha & Aishwath 2008)
- The use of bioinoculants *viz*., *Azospirillum* or *Azotobacter* as seed treatment and soil treatment in combination with 10 t sheep manure/ha could produce an estimated seed yield of 9 q/ha and thereby reducing the incidence of stem gall to 8% under semi-arid conditions (NRCSS)
- The eco-friendly technique of using 5% onion leaf extract as foliar spray three times protected the plants from powdery mildew as revealed from studies at Coimbatore
- The *Fusarium* wilt incidence can be better managed by seed pelleting with *Trichoderma viride* (with 10^6 CFU @4 g/kg of seed) plus neem cake application (150 kg/ha) (AICRP recommendation)
- The technique of soil solarization may be used for the control of weeds, disease and pests
- Organic module comprising soil application of vermicompost (5 t/ha), foliar spray of garlic extract (5% @2 kg/ha) + neem oil (2% @5 liters/ha, soil application of neem cake (150 kg/ha)

and *Trichoderma* (2.5 kg/ha), seed treatment with *Rhizobium* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed) resulted in maximum number of primary branches (8.05/plant), secondary branches (21.88/plant), number of umbels (32.22/plant), number of seeds (8.81/umbellate) and highest seed yield (1323.90 kg/ha) at ICAR-NRCSS, Ajmer (Lal *et al*. 2012)

Fennel (*Foeniculum vulgare* Mill.)

- As revealed from studies made at NRCSS, use of bioinoculant *Azospirillum* or *Azotobacter* as seed treatment and soil application with 10 tonnes/ha sheep manure could give 11.5 q seed yield/ha. *Azotobacter* inoculation to seed and seedlings prior to sowing/planting is advantageous as per studies made at Hisar under AICRP on Spices
- Application of 10 t/ha sheep manure or 4 t vermicompost along with seed inoculation by *Azotobacter* recorded higher growth and yield attributes over recommended doses of fertilizer (Meena *et al*. 2008)
- Application of sheep manure @10 tonnes/ha with bio-fertilizers (*Azotobacter*) resulted in significantly higher plant height (159.3 cm) and yield attributes *viz.*, umbel/plant (45), number of seeds per umbellate (50.3), seed (19.4 q/ha) and stover (23.7 q/ha), followed by application of vermicompost @4 tonnes per ha) with biofertilizers (Anonymous 2007)
- In the organic farming system, N supplied through compost + *Azotobacter,* P through rock-phosphate + S and K through feldspar, the yield tended to be lower but the essential oil yield was not affected significantly by fertilizer application with organic or conventional sources of N, P and K (Kandil *et al.* 2002)
- Sugary disease can be controlled by reducing the number of irrigation and the use of resistant variety *viz.*, Gujarat Fennel-1
- *Ramularia* blight can be controlled with incorporation of *Trichoderma viride* (4 g/kg of seed)
- Damping off in nursery can be controlled by prophylactic spray of 1% Bordeaux mixture

Cumin (*Cuminium cyminum* L.)

- Use of *Azospirillum* or *Azotobacter* in combination with 5 t/ha sheep manure per ha is suitable for organic crop production
- Wilt disease can be controlled by treating seeds with *Trichoderma* @4 g/kg seed, summer fallow of cultivated land and soil solarization during summer before sowing
- Seed inoculation of cumin with fungi *Gigaspora calospora*, *Glomus fasciculatum*, *Glomus mosseae* and *Acaulospora laevis*) not only reduced the incidence of wilt but also enhanced nutrient uptake (Champawat 1992)
- Use soil amendments like castor or mustard cake, poultry manure @2.5 t/ha before sowing also controls wilt disease
- Crop rotation with cluster bean- cumin, cluster bean-wheat and cluster bean-mustard also proved to be better for management of cumin wilt
- Use of *Fusarium* wilt resistant variety, GC-3.
- Late sowing minimizes incidence of blight

Fenugreek (*Trigonella foenium-graecum* L.)

- Application of 7.5 t/ha sheep manure with inoculation of seed by *Rhizobium meliloti* resulted highest growth and yield attributes as well as seed yield (894 kg /ha), gross return (Rs. 35760), net return (Rs. 19770) and BCR (1.24). However, increasing level of vermicompost with and without bio-fertilizer (2, 3 and 4 t/ha) exhibited higher growth and yield over their respective lower levels
- The combined application of *Azotobacter* with *Rhizobium* and *Pseudomonas striata* improved the growth, yield and nodulation (Parakhia *et al*. 2000).

- To control damping off, prophylactic application of 1% Bordeaux mixture was found effective (Restricted use is permitted)
- To control aphids, application of fish oil, rosin soap or neem seed kernel extract (3%), neem oil or tobacco decoction (0.05%) was found effective (AICRP recommendation)
- Organic module, comprising of soil application of vermicompost (5t/ha), foliar spray of garlic extract (5% @2 kg/ha) + neem oil (2% @5 litres/ha, soil application of neem cake (150 kg/ha) and *Trichoderma* (2.5 kg/ha), seed treatment with *Rhizobium* (100 ml/kg seed), PSB (100 ml/kg seed) and *Trichoderma* (10 g/kg seed) exhibited earliest seed germination and maximum plant height (5.78 cm, 19.69 cm, 43.39 cm and 50.97 cm) at 30 DAS, 60 DAS, 90 DAS and at harvest, respectively with maximum number of branches (6.76/plant), pods (42/plant) and seeds (16.01/pod) and highest grain yield (1515.21 kg/ha) at NRCSS, Ajmer

Future strategies to promote organic spice production

- Emphasis on newer approaches in plant breeding techniques for development of varieties resistant to biotic and abiotic stresses
- More intensive research is needed to work out economically viable cultural practices *viz.,* cropping pattern, crop rotation, intercropping, solarization, crop mixing and mulching
- Development of organic production technology using bio-fertilizers and biocontrol agents (PGPR) and soil amendments to control soil-borne diseases/pathogens
- Development and validation of forecasting models for blight, powdery mildew and aphids and use of effective and eco-friendly control measures for the disease and pests including storage pests
- Development of high-tech quality laboratories for analysis of cleanliness, quality standards, health standards as per international permissible limits for export of organic products
- Studies on use of natural, local and renewable sources and eco-friendly, pollution-free inputs *viz.,* organic manures, farm waste compost preparation *etc*.
- Systematic research for the development of holistic strategies based on integrated nutrient, disease and pest management approaches

Constraints in organic seed spice production

The seed spices are mainly grown in arid and semi-arid regions which are characterized by low rainfall with sparse vegetation. The prevailing high temperature along with sandy nature of soil results in fast decomposition of organic matter in the soil. This pose a biggest challenge for adoption of organic farming in seed spices. Moreover, crop like cumin is severely affected by blight under congenial atmospheric conditions resulting in complete crop failure. So far due to lack of availability of suitable bio-pesticides, it is not possible to practice organic cultivation in several seed spices. Besides above mentioned, other constraints of organic production are:

- Lack of awareness
- Output marketing problems
- High input costs
- Inadequate supporting infrastructure
- Shortage of bio-mass
- Marketing problems of organic inputs
- Lack of financial support
- Low yields
- Inability to meet the export demand
- Vested interests
- Lack of quality standards for bio-manures

- Improper accounting method
- Political and social factors

Conclusion

Production of seed spice organically in arid and semi-arid region of Rajasthan and Gujarat leads to efficient utilization of natural resources along with ensuring availability of good quality produce that fetches higher price in the domestic and international market. These water scarce regions (arid and semi-arid) with light soils are best suitable for the cultivation of seed spices. Certain monopoly high value crops predominant in this region like cumin and coriander have great international demand, if produced organically. Organic production of these spices will not only boost the economy of this region but also sustain the productivity of natural resources. The need is to develop easy and economic as well as viable technologies, development of processing and marketing infrastructure and financial as well as technical support for organic production.

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Strategies for sustainable spices production - Role of Spices Board

S Siddaramappa

Director (Development), Spices Board, Kochi-682025, Kerala
siddaramappa.s@nic.in

India is the single largest producer, consumer and exporter of spices in the world. The unique climate of India varying from sub-tropical to temperate is ideal for growing almost all the spices. No country in the world grows as many kinds of spices as India. The total spice production in the country is approximately 58.34 lakh tonnes from an area of 31.45 lakh hectares. The Indian spices like Guntur Sannam chillies, Byadagi chillies, Naga chillies, Alleppey finger turmeric, Erode turmeric, Lakadong turmeric, Cochin ginger, Malabar pepper, Alleppey green cardamom, Coorg green cardamom *etc.* are much sought in the International market because of their high intrinsic quality.

Due to the change in lifestyle, there is an increased preference for convenience foods and hence, the focus of demand has changed from whole spices to value added spices. Other than the food industry, spices are now well known for oil, oleoresins, health foods, cosmetics, nutraceuticals and medicinal properties. The stringent quality parameters imposed by the importing countries has shifted the focus to food safety, traceability, sustainability and fair trade. This has created an increased demand for organic spices.

About 6 million tonnes of spices are traded annually in India and more than 5 million growers and traders are engaged in spice trade. Spice sector contributes approximately Rs. 60,000croresto the agriculture sector of Indian economy through different supply chains.

Indian spice market

Export of spices (2014-15)

Total spice exports from India crossed $ 2 billion headingon its way to meet the target set for the year 2017 which is $ 3 billion. Presently, India enjoys 48 and 43 per cent share in terms of volume and value in the global spice market, respectively and commands a formidable position in the world spice trade. India exports only 12% of the spices produced and the remaining 88% is for domestic consumption.

During 2014-15, a total of 8,93,920 tonnes of spices and spice products valued Rs.14,899.67 crores (US $ 2432.85 million) has been exported from the country as against 8,17,250 tonnes valued at Rs.1,37,353.92 crores (US$ 2267.67 million) in 2013-14 (Table 1).

Table 1. Export of spices from India during 2013-14 and 2014-15

Spice	**2013-14**		**2014-2015**	
	Qty. in tonnes	**Value in Rs. lakhs**	**Qty. in tonnes**	**Value in Rs. lakhs**
Pepper	21,250.00	94,002.34	21,450.00	120,842.16
Cardamom(S)	3,600.00	28,380.88	3,795.00	32,346.75
Cardamom(L)	1,110.00	7,961.15	665.00	8,403.90
Chilli	3,12,500.00	272,227.20	347,000.00	351,710.00
Ginger	23,300.00	25,614.27	40,400.00	33,133.00
Turmeric	77,500.00	66,675.85	86,000.00	74,435.00
Coriander	45,750.00	37,185.65	46,000.00	49,812.50
Cumin	121,500.00	160,006.00	155,500.00	183,820.00
Celery	5,600.00	3,661.48	5,650.00	4,302.10
Fennel	17,300.00	16,001.42	11,650.00	13,165.50
Fenugreek	35,575.00	13,378.37	23,100.00	13,947.63
Other seeds (1)	27,800.00	15,425.65	28,250.00	16,512.50
Garlic	25,650.00	8,387.05	21,610.00	8,183.00
Nutmeg & mace	4,450.00	26,285.62	4,475.00	26,797.50
Other spices (2)	34,700.00	41,846.80	36,500.00	44,915.00
Curry powder	23,750.00	40,132.03	24,650.00	47,626.00
Mint products (3)	24,500.00	343,042.20	25,750.00	268,925.00
Spice oils & oleoresins	11,415.00	173,324.85	11,475.00	191,090.00
Total	**817250**	**1373539.26**	**893920**	**1489967.53**
Value in million US $	**2267.67**		**2432.85**	
(1) Includes mustard, aniseed, Bishops weed (ajwain seed), dill seed, poppy seed *etc.*				
(2) Includes asafoetida, cinnamon, cassia, cambodge, saffron, spices *etc.*				
(3) Includes mint oils, menthol & menthol crystals				

Source: DGCI & S, Kolkatta/ shipping bills/ exporter's returns

Table 2. Major markets for Indian spices

Country	**Major items**
U.S.A	Mint items, spices oils & oleoresins, pepper, chilli, turmeric
China	Mint products, chilli, spice oils & oleoresins
Malaysia	Chilli, turmeric, coriander, cumin, fennel
U.A.E	Turmeric, chilli, nutmeg, curry powder, cumin
U.K.	Spices oils & oleoresins, mint products, chilli
Bangladesh	Chilli, turmeric, garlic, ginger, cumin
Germany	Spices oils & oleoresins, mint products, turmeric
Pakistan	Chilli, large cardamom, cumin, coriander
Japan	Spices oils & oleoresins, mint products, turmeric
Sri Lanka	Chilli, turmeric, coriander, cumin, fennel
Saudi Arabia	Small cardamom, curry powder, turmeric, ginger

Singapore	Spices oil& oleoresins, mint products, chilli
South Africa	Spices oils & oleoresins, turmeric, chilli, coriander
Netherlands	Spices oil& oleoresins, mint products, turmeric, pepper, chilli
Mexico	Spices oil& Oleoresins, mint products, cumin, chilli
Brazil	Spices oil & oleoresins, mint products, cumin, chilli

Import of spices (2014-15)

The import of spices during 2014-15 was 1,38,715 tonnes valued at 3843.82 crores (US $ 629.36 million). The import of spices is for domestic consumption, value addition and re-exports. Spices such as clove, poppy seed, cinnamon, ginger fresh and cardamom (large) are from neighbouring countries for domestic consumption and black pepper, crude spice extracts for value addition and re-export.

Functions of Spices Board

Spices Board, under the Ministry of Commerce and Industry, was constituted on 26^{th} February, 1987 as per the Spices Board Act, 1986 by merging the erstwhile Cardamom Board and Spices Export Promotion Council. The Board is headed by a Chairman with its head office in Kochi and is responsible for the development of cardamom industry and promoting the export of all the 52 spices listed in the schedule of Spices Board Act, 1986. The mandate for research, production, processing and domestic marketing of spices other than cardamom is vested with the Union Ministry of Agriculture and State Governments.

The key components

Production

The Board extends support for production, processing, domestic marketing and export promotion of cardamom (small and large). The main objective is to produce exportable surplus of cardamom (small and large) and therefore, the programmes are formulated for production and productivity increase, sustainability and quality improvement for exports. Small cardamom is mainly grown in western ghats of Kerala, Karnataka and Tamil Nadu and large cardamom in the sub-Himalayan tracts of Sikkim and Darjeeling districts of West Bengal. The programmes includes assistance to growers for,

- Planting material production
- Re-plantation
- Improved cardamom curing devices
- Irrigation and land development programmes
- Supply of GAP kits
- Supply of bee keeping boxes
- Mechanization (supply of pit makers, weed cutters, plant protection equipments, washing equipments, graders/sieves and polishers)

Development of spices in North Eastern states

Development of spices in North-East has been a priority of Spices Board since this region produces a variety of spices like pepper, large cardamom, ginger, turmeric, Naga and Bird's eye chillies. Spices cultivated in NE are popular due to its intrinsic qualities unique to North-East. By and large, the spices produced in this region are organic and are close to nature and most preferred by consumers all over the world.

Department of Horticulture, Government of Arunachal Pradesh entered into MoU with Spices Board for development of spices in Arunachal Pradesh on 26.10.2014.

Spices Board is implementing programmes for development of large cardamom and other spices such as Lakadong turmeric, ginger and Naga Chilli. Board assist the farmers for promoting organic cultivation of spices, certification, promoting mechanisation in post harvest improvement, establishment of primary processing units and formation of spice producer's societies.

Post harvest improvement of spices

Like all other agricultural commodities, spices invariably contain high moisture (55-85%) at the time of harvest which has to be brought down to 8 to 12% for safe storage. Post-harvest handling should ensure proper conservation of the basic qualities like aroma, flavour, pungency, colour *etc.* as well. Due to ill organised and inadequate post harvest practices, the exportable spices are often found contaminated by microbes, insects, extraneous matter, thereby causing damage to India's share in the world spice market.

Spices Board is addressing these issues to educate growers on post harvest operations through following Board's programmes and publicity awareness campaigns.

Post harvest improvement programmes for spices

- Pepper threshers
- Pepper cleaning and grading units
- Ladders for clove pepper
- Supply of bamboo mats
- Seed spice thresher
- IPM in chilli
- Supply of polythene sheets
- Turmeric boilers and polishers
- Mint distillation units
- Spice washing equipments
- Spice slicing machines
- Nutmeg/ tamarind dehuller
- Nutmeg drier
- Herbal spice extraction/dehydration units
- Primary processing units for ginger, garlic, seed spices and organic spices

Social security programmes

Spice producers societies

Board encourages the formation of spice producer’s society and these societies will function as nodal centres for dissemination of information to farmers, who are members of the society and act as bridge linking the Board and the farmers. If equipped, these societies can collectively go for organic farming, primary processing which could be done for conventional spices also. Similarly training programmes could be arranged through these societies. In addition to the formation of spice producer’s societies (SPS), it is proposed to promote processing and value addition at primary level for whole spices. Assistance will be given to registered SPS for drying, cleaning, grading and packing of whole spices. 50% of the cost of the primary processing equipments and basic infrastructure subject to a maximum of Rs. 6 lakhs per SPS is provided as grant in aid. Production of quality spices adhering to GAP and

GMP will help them to a premium price for their produce. Backward linkage, direct procurement by exporters can be linked to the SPS by eliminating the role of intermediaries for a better price realization. These groups can function as nodal groups for promoting traceability in spices.

Extension advisory scheme

Extension visit & meeting

Transfer of technical know-how to growers on production and post harvest improvement of spices is an important factor in increasing productivity and improving quality of spices. This programme envisages technical/extension support to growers on the scientific aspects of cultivation and post harvest management through personal contact, field visits, group meetings and through distribution of literature in vernacular languages for development of small cardamom in the states of Kerala, Karnataka and Tamil Nadu & large cardamom in the states of Sikkim & West Bengal and selected spices in the North East region and post harvest improvement in other spice growing regions.

Export development and promotion

The marketing programmes are aimed at equipping the exporters to have the necessary competitive edge in sustaining and increasing export market for Indian spices. The different programmes under this category includes:-

a) Infrastructure improvement, b) trade promotion, c) product development and research, d) market study abroad, e) promotion of Indian spice brands abroad, f) spice parks for common processing facilities, g) participation in International fairs/meetings/ seminars/trainings, h) promoting organic/ medicinal value of spices and i)GI registration.

Activities also include sampling and testing of selected spices for ensuring quality standards and regulatory functions.

Quality evaluation and control

The quality evaluation laboratory of the Board carries out the mandatory pre-shipment quality checking of export consignments of chilli, chilli products, turmeric powder and nutmeg, provides training to technical persons on physical, chemical and microbiological analysis and renders quality evaluation services for the spice industry.

Research

The research wing of Spices Board conducts mobile agri clinic services, residential training on GAP to unemployed youths, research on organic farming systems, varietal trials, mechanizing the production and post harvest operations, weather forecasting and production and supply of bio-agents to farmers, soil fertility mapping and advisory services.

Initiatives of Ministry of Commerce & Industry

Setting up of spice development agencies

The Ministry of Commerce & Industry, Govt of India has established 10 Spice Development Agencies in the major spice production/marketing centres across the country. The Spice Development Agency is chaired by the chief secretary of the concerned State Govt. and has 17 members representing various stakeholders *viz.* Central/ State Govt officials, SAU, SHM, JDGFT, farmers, exporters, traders *etc.* The Regional officer of the Spices Board in the state is the member secretary of the concerned SDA. The SDAs are established in Erode in Tamil Nadu; Haveri in Karnataka; Guntur in Andhra Pradesh; Guna in Madhya Pradesh; Mumbai in Maharashtra; Unjha in Gujarat; Jodhpur in Rajasthan; Barabanki in Uttar Pradesh; Gangtok in Sikkim and Guwahati in Assam.

The functions of SDAs, inter alia, will co-ordinate programmes, activities and projects of the concerned agencies of Central and State Governments relating to production, development, promotion, marketing and export of spices; undertake programmes and projects in particular, for export promotion of spices; arrange to provide assistance for improved method of cultivation, replanting and expansion of growing area under spices and its processing and packaging; carry out promotional programmes to increase consumption of spices; assist and encourage studies and research for improvement of processing, quality, techniques of grading and packaging of spice; advise the Central Governments, State Governments of the region and Spices Board on matters related to production, marketing, quality and export of spices.

Establishment of saffron production and export development agency

To develop and promote export of quality saffron, the Department of Commerce, Govt. of India has established a Saffron Production and Export Development Agency (SPEDA) headed by the Secretary, Department of Commerce, Govt. of India, having its Head quarters at Srinagar.

Initiatives of Spices Board

(1) Electronic auction system for cardamom

The electronic auction (e-Auction) system introduced for cardamom is functioning successfully at two centres, *viz*. in the Spices Park at Puttady in Kerala and Bodinayakannur in Tamil Nadu with infrastructure facilities provided by the Board.

Spices Board re-introduced auction system in large cardamom to ensure transparency and better realization to the farmers. The auction is conducted at Spices Board office at Rangpo in East Sikkim. North Eastern Regional Agricultural Marketing Corporation Ltd (NERAMAC) is the nodal agency conducting the auction.

(2) Codex committee on spices & culinary herbs (CCSCH) – a giant leap towards harmonization of quality standards

The Secretariat of CCSCH under Codex is set up in Spices Board which is an inter-governmental platform for setting up of standards for Spices and Culinary Herbs to achieve the objectives of fair practices in trade and consumer safety.

(3) Preparation and submission of integrated projects to various states for development of spices

The spices are generally considered as minor crops and do not receive adequate consideration/ priority as warranted by the potential of their contribution to growth in incomes and employment. Keeping this in view, Spices Board has prepared Integrated Spices Development Projects consisting of production, post harvest and HRD programmes and submitted to 29 State Governments and 6 Union Territories. The programmes are under various stages of approval. The Govt of Andhra Pradesh and Govt of Telangana have approved the integrated projects submitted by Spices Board under RKVY and the schemes are being implemented by the State Dept of Horticulture and Spices Board. Recently, the Govt of Assam has approved the integrated spice Project submitted by Spices Board under RKVY. The implementation of the programmes will be commenced shortly.

The integrated projects envisage that production components of the project will be implemented by the State Governments/designated agencies; while post harvest programmes will be implemented by Spices Board.

(4) e- Spice Bazaar: e-commerce platform for better market reach and price realization of chilli farmers in Andhra Pradesh & Telangana

The e Spice Bazaar is an e Governance project being implemented by the Spices Board, funded by the Department of Electronics and Information Technology (under the Ministry of Communications and IT) to ensure traceability of spices produced in the country. The first phase of the project is on chillies produced in Andhra Pradesh and Telangana which has commenced during this sowing season through formation of farmer groups and creation of farmer registry with Global Location Number (GLN)to the farmers for the traceability.

(5) Collaborative Training Cell (CTC)

A training centre exclusively for addressing the challenges of quality and food safety in spices is set up in Spices Board. A tripartite agreement was signed by JIFSAN- University of Mary Land, Spices Board and CII-FACE. The centre will help to provide cost effective technical consultancy services to the sector for making the spices sector globally competitive.

(6) National policy on spices

Board on the deliberations of the National conference held at New Delhi on Development and Export of Spices, a road map has been prepared and submitted to both the Ministry of Commerce & Ministry of Agriculture. It was suggested in the conference that a national policy for development of spices is essential for increased production, quality improvement, organized marketing and thereby creating more employment opportunities in rural India for the socio-economic development of rural spice farmers.

As per the deliberation, Ministry of Agriculture, New Delhi, has already constituted a Task Force Committee and convened the meeting for National Policy on Spices. The Task Force is expected to submit its report shortly.

(7) Flavourit – Brand for quality spices

Spices Board promotes finest quality spices across the globe through Flavourit Spices Trading Ltd (FSTL), a subsidiary of Spices Board. “FLAVOURIT”, an authentic brand owned by Spices Board aimed at promoting quality spices & value added products, streamlining the efforts of spice growers working at grassroots with the market forces. Flavourit is also aimed to create a spice growers society to help farmers work collectively so as to achieve the better market prices.

(8) "Spices india- flavourfully yours" - Signature stall of Spices Board

An initiative of Spices Board, serving as an experimental centre -cum retail store:-

- To showcase spices and value added products in a state of the art infrastructure.
- To establish and promote a unique brand image about Indian spices.
- Offer an environment for the customers to touch, smell and feel the spices.
- Educate on the various culinary, nutraceutical and medicinal uses of spices.

Presently, Spices Board has 3 Signature stalls *viz*., (1) Lulu Mall, Kochi, Kerala (2) STC Building, New Delhi (3) Delhi haat, Janakpuri, New Delhi

Vision of the spice industry

To become an international processing hub of spices and premier supplier of high quality and value added spices and herbs to the domestic as well as international market.

Conclusion

With the entry of more countries in spice production and trade, the position of India in the world market is becoming more competitive. There is a strong felt need to enhance the production/ productivity level of spices in the country to make available the commodities at competitive prices and also to improve the quality of the produce adopting the latest technology. There is scope for area expansion of export suitable varieties of spices.

The integrated projects submitted by Spices Board for development of spices to the State Governments and Union territories need to be considered for approval by the State Governments/ Union territories under MIDH/ RKVY for sustainable development of spices in the states.

Central and State Government agencies are implementing various programmes to the farming community for spice development. Since various institutions are working in parallel in spices, there should be synergy among the departments and converge their programmes for focused development of spices.

As soon as National Policy on spices proposed by Ministry of Agriculture as desired by Ministry of Commerce & Industry, comes in to existence, there is scope for sustainable production of quality spices for domestic consumption as well as export of spices from the country.

L17

King of spices under the tree of life

O V R Somasundaram

Odayakulam, Pollachi, Coimbatore-642129, Tamil Nadu
ovrsomu@gmail.com

Black pepper is the most important spice of the world and is called as the 'King of Spices'. Though black pepper originated in India and is widely cultivated for many centuries, its productivity in the country has declined. Currently, the productivity of black pepper is the highest in Vietnam and Cambodia. Black pepper is cultivated as a monocrop in these countries under intensified cropping system besides the favourable climatic conditions prevailing particularly during summer where the temperature never exceeds 32°C.

Among the various spices consumed world over, black pepper is the only spice which inevitably finds place in almost all types of cuisines. This is the only spice commodity in which the procurement price remains at a stable price. Spices like nutmeg face high fluctuation in market, however, black pepper is the only crop which commands better price consistently (Rs.700/kg) and the prices have never dropped below Rs.300/kg in the past. The reason for declining productivity in India, particularly the western ghat region is the climate change, poor fertility of the soil, increasing menace of diseases.

In Tamil Nadu, Pollachi leads in coconut cultivation in which multiple cropping is practiced allowing remunerative raising of intercrops which is virtually impossible with many other perennial trees. Nutmeg, cocoa, banana, turmeric, ginger are the major crops grown under mixed cropping. Black pepper is cultivated to a meagre extent randomly. Black pepper can be a successful crop under well grown coconut plantation. The success of black pepper can be determined by factors viz., choice of variety, use of disease free planting material, shade management, soil fertility measures. Black pepper is one of the best companion crops in coconut and responds well to irrigation, Pollachi would command more area under black pepper in due course of time. Ample scope exists for introduction of black pepper in widely spaced coconut plantation in this region by planting *Gliricidia* as standard in between coconut palms.

Of the numerous varieties available in black pepper, Panniyur-1 and Karimunda performs well under the plains of Tamil Nadu, particularly Pollachi. To introduce black pepper as intercrop in coconut, *Gliricidia* should be raised as standard. The limb cuttings of *Gliricidia* can be planted in two rows at 6 feet in such a way that the alternate rows of *Gliricidia* are planted in a zig zag way to facilitate rooting and penetration of sunlight. The advantage of growing *Gliricidia* is that it provides high biomass which is beneficial to soil being a leguminous crop and good shade regulator for black pepper. Rooted cuttings of black pepper should be planted closer to *Gliricidia* and allowed to train on *Gliricidia*. Unlike the runner shoots used for propagation under conventional method, black pepper is now propagated through orthotropic shoots which are better in terms of early yield and high yield.

Institutions like, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala Agricultural University and Tamil Nadu Agricultural University have the required expertise to grow black pepper and the farmers who are interested in introducing black pepper under coconut plantation in plains are advised to take the consultancy services of these institutes before planting. The planting material should invariably be accessed from these institutes only.

L18

Vanilla from India - an Opportunity revisited

R Mahendran

Expovan & Indian Vanilla Initiative (P) Ltd., Pollachi, Tamil Nadu
drmahendranmd@gmail.com

The contribution of Vanilla (*Vanilla planifolia*) from India to the global vanilla production has been insignificant thus far. At the same time, this opportunity still exists for India.It is a time of introspection of why it was not capitalized fully and on the opportunity that still exists. The period between years 2000 to 2010 saw a spurt in vanilla production in India mainly from Karnataka, Kerala and Tamil Nadu of South India, with production reaching almost 2000 tonnes of green vanilla in the year 2009. However, collectively it was not a great success and a clear understanding of the reasons for the lack of success and the way these could be addressed have allowed us to pave the way in capitalizing on the opportunity that is still available.

To compete in the global vanilla market, three important aspects are required to be followed in the vanilla supply chain:

Cultivation of vanilla

Sustainable methods of cultivation, guidance in all nuances right from site selection, planting, cultivation techniques, traceability, certifications and auditability now through the organized channel of Indian Vanilla Initiative**.**

Vanilla processing/Global marketing

Techniques which yield a homogeneous high-quality product masterminded over two decades through Expovanwith an understanding of best practices of quality, grading and handling.

Domestic marketing

Direct access to Indian market by understanding requirement of the population and industry throughIndian Vanilla Enterprise**.**

This presentation by Dr. Mahendran R. from India, whose association with vanilla in India goes back a long way since the early 90's, right from cultivation to processing and now also in marketing of vanilla products for the Indian consumer, gives an insight into vanilla from India, the past and the present revival and to the potential future contribution of India to sustainable vanilla production.

Success in vanilla

- In vanilla, his detailed study since 1992 into cultivation and processing led him to a joint venture with a French company for processing and marketing of Indian vanilla worldwide from 2004 until 2014, going on to become a major and arguably the only success story of vanilla in India.
- In vanilla, his success has led to a renewal of interest of the major consumer companies in vanilla in the West and they want to guarantee the long-term supply chain in vanilla of major

volumes through him, what he now terms as an opportunity in vanilla in India to revisit, for both the growers and the end users.

- He now independently runs his vanilla business, from cultivation, processing, value addition and marketing.
- He has founded a company, “Indian Vanilla Initiative”, which offers vanilla cultivation expertise to the grower, with guarantee of 100% buy-back of green vanilla, which is to be processed/value added and marketed worldwide through his company “Expovan”.
- Last year, he has launched Indian vanilla for the Indian consumer industry through his company “Indian Vanilla Enterprise “, under the brand “Goodness Vanilla”.
- Industrial users such as Ibaco ice creams and Aavin farm are some of the companies that have already launched real Vanilla products over the previous year in India.

PEPPERRIDGE BIOSOLUTIONS LLP

Post Box No. 59, Suntikoppa Post, Kodagu Dist. Karnataka - 571 237 | Tel: 08276-275372, Mob.: 94827 51372, E-mail: pepperridge@gmail.com

For the past few years Black Pepper has saved many planters. But unfortunately pepper vines both young and mature have been dying at alarming rates due to bacterial, fungal and pest related causes all over the planting districts. Because of the importance of pepper to their incomes, planters have continued to replant again and again with pepper plants from their own estate nurseries or purchased from local commercial nurseries,but the loss of Pepper plants has not stopped or even slowed down.This is because the soil that they or any commercial nursery use to raisetheir pepper is deemed to be contaminated by all Pepper Research institutions.

What is the answer? It may lie with the plants being produced by a new State of the Art commercial pepper nursery established in Suntikoppa Kodagu – **Pepperridge Biosolutions LLP.** National Horticulture Certification is under process.

REASONS TO CONSIDER OUR PEPPER PLANTS

Because we do not use soil as the basic material for rooting and growing cuttingsin ournursery baskets we use a sterilized organic fibrous non-soil rooting andgrowth medium instead of soil. This way we completely avoid any soil borne contamination of our nursery plants.

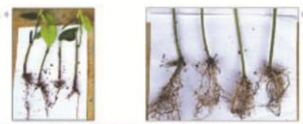
- All the material used in our baskets is fully organic. No chemicals or artificial additives.
- The root systems of plants germinated in thisspecially preparedgrowth material has shown greater growth and spread than those produced in soil based nurseries. Plus our plants have shown much faster germination and are much longer compared to soil based plants of the same time period.
- Therefore the planter is getting an infection free and much healthier pepper plant.
- For these reasons our pepper plants are a generation more advanced than traditional pepper nurseries.
- Every time aplanter loses a pepper vine on the estate he/she loses at least 5 years of income from thatvine.
- At the rate pepper vines are dying today (From a minimum of 10% to more than40% in many estates)planters are losing major income for years.

SO WHY NOT PLAY SAFE ?

Start by buying uncontaminated plants and planting them. Why take a risk with soil based nursery plantsof your own or purchased from commercial soil based nurseries just because they may be a bit cheaper

Pepperridge Biosolutions LLP is now the only Non- Soil Basedcommercial pepper nursery in India todayand the first pepper nursery to apply for National Certification.

- Our plants will be ready for sale in the third week of August. Place your orders early to be guaranteed a supply.



- This is our first year. The Pepper plants available are Panniyur – 1 variety. We will have many more Hybrid varieties next year. Given below is our order placing details with phones and addresses.

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- Our sale prices and reservation advance prices will be provided by our Sales Team on contact.

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&

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Indian Society for Spices

The Indian Society for Spices was founded in 1991 for the advancement of research and development of spices, aromatic, medicinal and related crops. The society aims at providing a forum for research workers on these crops for exchange of ideas, and as a catalytic link between research and development organizations and the industry. The society organizes symposia, conferences and seminars in collaboration with other organizations on aspects relevant to spices, aromatic and medicinal crops. The society fosters to the professional interest of research workers on spices, medicinal and aromatic crops through its journal, the Journal of Spices and Aromatic Crops, which is available free of cost to members. Members also receive publications of the society at reduced cost and can participate in scientific meetings and other functions of the society.

Membership rates

Patron	: Rs 50,000
Sustaining member	: Rs 25,000
Institutional member	: Rs 5,000
Life member	: Rs 3,000
Ordinary member (annual)	: Rs 750

For membership, contact

The Secretary
Indian Society for Spices
Indian Institute of Spices Research
Marikunnu P.O., Kozhikode-673012
Kerala, India
iss@spices.res.in, isscalicut@gmail.com
www.indianspicesociety.in

Journal of Spices and Aromatic Crops

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