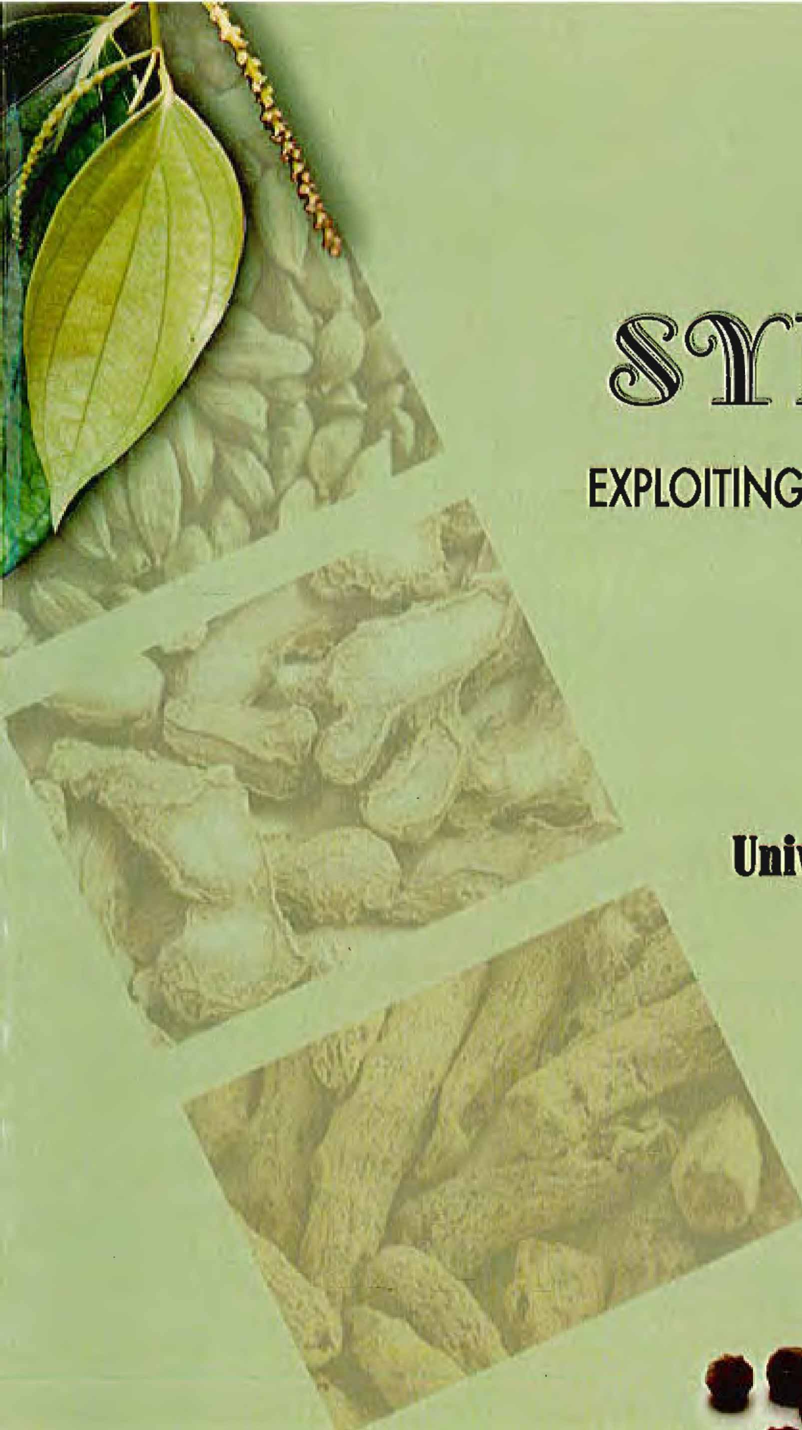

Souvenir

SYMSAC~VI

EXPLOITING SPICES PRODUCTION POTENTIAL OF THE DECCAN REGION

8-10 December 2011

University of Agricultural Sciences
Dharwad

Organized by

Indian Society for Spices
Kozhikode, Kerala

Directorate of Arecanut and Spices Development
Calicut, Kerala

University of Agricultural Sciences
Dharwad, Karnataka

In Collaboration with

Indian Institute of Spices Research
Kozhikode, Kerala

Indian Council of Agricultural Research
New Delhi

NATIONAL SYMPOSIUM ON SPICES AND AROMATIC CROPS
(SYMSAC VI)

Exploiting Spices Production Potential of the Deccan Region

8-10 December 2011
University of Agricultural Sciences, Dharwad

SOUVENIR & ABSTRACTS

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Directorate of Arecanut and Spices Development, Kozhikode, Kerala
University of Agricultural Sciences, Dharwad

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Souvenir and Abstracts

National Symposium on Spices and Aromatic Crops (SYMSAC VI)
Exploiting Spices Production Potential of the Deccan Region
8-10 December 2011, University of Agricultural Sciences, Dharwad

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Indian Society for Spices, Kozhikode, Kerala
Directorate of Arecanut and Spices Development, Kozhikode, Kerala
University of Agricultural Sciences, Dharwad, Karnataka

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Dr. H. P Singh
Deputy Director General (Horticulture)
Indian Council of Agricultural Research
Krishi Anusandhan Bhavan II
Pusa, New Delhi – 110 012.

MESSAGE

It gives an immense pleasure to know that Indian Society for Spices, Calicut is organizing the Sixth Symposium on Spices and Aromatic Crops (SYMSAC - VI) on exploiting spices production potential in the Deccan Region from 8 to 10 December, 2011, at University of Agricultural Sciences, Dharwad.

National efforts of research and development for spices has paid dividend in terms of increased production and productivity. India has emerged as largest producer and exporter of apices in the world. The growing economic importance of spices could be attributed to an increasing demand arising from domestic as well as overseas market. The spices crops particularly chilli, coriander, turmeric, ginger, black pepper and ajwain are essential to the livelihood of many marginal farmers in the Deccan region and are emerging as important crops in horticulture. However there is a growing competition, which demands competitive quality of spices world over. This has to be produced at less cost to ensure better returns to farmers. Thus, there is a need to address the challenges. I am sure, the symposium will deliberate upon the issues emerging in production of spices in Deccan region and develop an action plan for innovations to enhance the production to meet the needs of domestic and export market.

I wish the symposium a grand success.

[H.P. Singh]

Place: New Delhi
Date: 30.11.2011

Dr. R. R. Hanchinal
Vice-Chancellor
University of Agricultural Sciences
Dharwad – 580 005.

MESSAGE

I am glad to learn that the Indian Society for Spices in collaboration with the Directorate of Arecanut and Spices Development, Calicut and University of Agricultural Sciences, Dharwad is organizing a symposium on exploiting spices production potential in the Deccan region.

The Deccan region is known for rainfed agriculture and hence is an entirely different farming system from that practiced in the irrigated areas. Hence, mixed cropping systems involving spices would offer better options against single crop failure. While doing so, let us not ignore the basic principles under lying rainfed agriculture. In this region the average size of farmers holding is 0.39 ha, while a small farmer typically farms 1.43 ha. Deriving a livelihood from such a small area can be quite a challenge, especially in dryland areas, where rainfall is not only low but also erratic. As a result, water is a scarce resources and soil is fragile. However, ample scope exists, for increasing the production and productivity through adoption of improved production technology. Besides, there is an urgent need to address issues such as low yield, biotic and abiotic stresses, stringent IPR measures, marketing and processing.

I trust that this symposium will address these issues, identify the gaps, provide solutions and offer us valuable insight to augment spice production in this region. I appreciate the efforts of ISS, DASD (Calicut) and UAS (Dharwad) for organizing this symposium on exploiting spices cultivation in the Deccan region.

[R.R.HANCHINAL]
VICE-CHANCELLOR

Place: Dharwad
Date: 30.11.2011

FOREWORD

THIS souvenir is a compilation of lead lectures and abstracts that will form a part of the sixth National Symposium on Spices and Aromatic Crops (SYMSAC VI) to be held at UAS, Dharwad from 8-10 December 2011. The focus of this symposium is on Exploiting Spices Production Potential of the Deccan Region. This symposium is jointly organized by the Indian Society for Spices, Kozhikode; the Directorate of Arecanut and Spices Development, Kozhikode and University of Agricultural Sciences, Dharwad and is intended to bring together a group of people who are willing to imbibe and share knowledge and put it to good use for exploiting the potential of the Deccan region for spices production.

THE Symposium covers major themes like genetic diversity and conservation, quality planting material availability, plant health management, secondary agriculture and socio economic issues in production and marketing of spices, medicinal and aromatic crops. Each session will address a different theme with eminent scientists sharing their research experience through their lead talks. Poster sessions will further explore the thematic areas. The editors of this compilation have tried to ensure that the lead papers and abstracts in this souvenir cover a wide range of topics specifically intended to provide the necessary impetus to exploit the spices production potential of the Deccan region. The ultimate result is the collection of high quality lead lectures and abstracts on various facets of spice cultivation.

WHILE, this compilation gives only a whiff of what could be possible in the Deccan region, it does provide the necessary kick start needed to usher in a new outlook towards cultivation of spices and aromatic crops in this region. The Deccan region with its complex environment does provide ample challenges to spices researchers. Conversely it also provides a gamut of exciting possibilities that would spice up its economy.

I am thankful to Dr S. Ayyappan, Director General (ICAR), Dr. H.P. Singh, Deputy Director General (Horticulture) and Dr R. R. Hanchinal (Vice Chancellor, UAS, Dharwad) for their strong encouragement and guidance to conduct this national symposium. I am also grateful to Dr M. Tamil Selvan, Director, DASD, Kozhikode for all the support given to us. I acknowledge the efforts of the organizing secretary at UAS, Dharwad, Dr P. R. Dharmatti and his team for the successful conduct of SYMSAC VI. I am also grateful to the Secretary of ISS, Dr V. Srinivasan for his strenuous efforts to organize this symposium as well as his dedication to manage the day to day affairs of the Society. Thanks also to the editors of this compilation.

(M. Anandaraj)
President, ISS

CONTENTS

The Indian Society of Spices and its relevance to spices research and development

M. Anandaraj
President (ISS) and Director
Indian Institute of Spices Research, Kozhikode, Kerala

In the western countries, the contribution of scientific societies in the development of science and technology is well known. Similarly, in the contemporary non-western world, serious efforts are being made through scientific societies to foster indigenous research. In India, scientific societies have served as a platform to explore scientific developments from a variety of perspectives. The scientific societies have played a crucial role in helping integrate a complex and varied scientific system.

The Indian Society for Spices (ISS) was founded in 1991 for the advancement of research and development in spices, aromatic 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 and aromatic crops.

Aims and objectives of ISS

- To provide common forum for the workers in spices, aromatic plants and allied crops for purposeful exchange of ideas
- To publish an International Journal called Journal of Spices and Aromatic Crops, as a vehicle for speedy publication of research results
- To encourage interaction among scientists of different organizations in India
- To organize symposia, conferences, workshops etc on spice, aromatic and related crops
- To act as an effective catalytic link between the research and development organizations on one hand and the industry and trade on other, and
- To further the concept of common brotherhood among research workers, development workers, farmers, industrialists, traders and the consumers of spices, aromatic plants and allied crops.

The ISS and scientific literacy

The term *scientific literacy* comprises an understanding of the basic concepts of science, the nature of science, the ethics that control scientists in their work, the interrelationships of science and society, the interrelationships of science and the humanities, and the differences between science and technology – with the first three categories being designated as the most significant (Pella et al.,1966). According to Osborne (2000) and Hodson (2003), scientific literacy can be perceived in four different ways:

Cultural: Developing the capacity to read about and understand issues pertaining to science and technology in the media.

Utilitarian: Having the knowledge, skills and attitudes that are essential for a career as scientist, engineer or technician.

Democratic: Broadening knowledge and understanding of science to include the interface between science, technology and society.

Economic: Formulating knowledge and skills that are essential to the economic growth and effective competition within the global market place.

The ISS does advocate such scientific literacy by attempting to bring about an understanding of the interface between the science of spices and aromatic crop production/ marketing, technology development/ generation and the environment. A key goal is to help scientists realize the significance of their research output and foster a voice of active involvement in research and development of our crops. This helps not only to enhance the knowledge and capabilities of the scientists, but also to encourage interaction and collaborative connections with the farmers and entrepreneurs. The ISS also advocates reforms that would equip farmers to understand scientific developments in their cultural, economic, political and social contexts. This was considered important in making science accessible and meaningful to all—and, most significantly, engaging them in real world issues.

At best, the ISS can be considered as a movement that promotes interdisciplinary approach to research involving an integration of all facets of scientific and technological developments in spices and aromatic crops. Our society has been involved in engaging scientists in examining a variety of issues and generating scientific knowledge on real world issues which might cause serious impacts like global warming, genetic engineering, deforestation practices, and environmental legislations related to spices and aromatic crops. Besides, we have enabled researchers to formulate a critical understanding of the interface between science, technology and the farming society and helped in developing our capacities and confidence to make rapid decisions.

I would be seriously remiss, if I fail to mention that the primary aim should largely be directed towards fostering scientific exchange and enhancing scientific literacy levels keeping in mind the *real-farm* issues. Apparently, we need to broaden our comprehension of science involving spices and aromatic crops, and be prepared for unforeseeable threats to these crops. Hence, the scope of ISS needs to go beyond learning about scientific theories, facts and technical skills. We need to know how and when our knowledge can and should be utilized, how to recognize deficiencies in our knowledge and how to compensate for them. This is one major reason why the ISS set in motion the SYMSAC series.

ISS and spices production

The society deals with all information on research and development of spices and aromatic crops. Spices are high value and low volume commodities of commerce in the world market. All over the world, the fast growing food industry depends largely on spices as taste and flavor makers. Health conscious consumers in developed countries prefer natural colours and flavors of plant origin to cheap synthetic ones. Thus, spices are the basic building blocks of flavor in food applications. 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 112 plant species listed as spices by International Standards Organization and India grows about 60 of these spices. Almost all States in the country produce one or other spices. During the crop year 2009-10 the country produced about 4015.9 thousand tons from 2463.7 thousand hectares of area under spices. Of the total production, nearly 12% was exported. Share of export in total production varied from a mere 0.6% in tamarind to about 72% in nutmeg and mace. During 2010-11, export in terms of value was all time high with US $ 1.5 billion. This underlines how important spices are to our economy and obviously means that we need to enhance our productivity to hitherto unprecedented levels in the coming years. This is where scientific literacy and exchange of scientific information on spices and aromatic crops becomes imperative. The ISS ideally does this by creating a platform to express opinions and take responsible action to address critical issues in spices and aromatic crop production and marketing. In other words, the ISS promotes the study of spices and aromatic crops by fostering interdisciplinary communication among scientists, holding conferences, and publishing the Journal of Spices and Aromatic Crops (JOSAC). The open discussion on scientific topics through SYMSAC is indicative of how vibrant the society is after the launch of the symposium series.

ISS and JOSAC

The Journal of Spices and Aromatic Crops (JOSAC) is the official publication of ISS, which is published twice a year during June and December. It is an international journal devoted to the advancement of spices, aromatic and related crops. The journal publishes multidisciplinary reviews, research articles, research notes and book reviews on all aspects of spices, aromatic and allied crops. Originally given a rating of 2.0, the journal is presently rated at 3.9 by the National Academy of Agricultural Sciences, New Delhi. The journal is available online at http://www.indianspicesociety.in/josac/index.php/josac.

Conclusions

It would be cliché to say that we are living in an age of rapid and far-reaching change, an era of rising expectations where we expect changes to occur more rapidly. But this does stress the fact that, we as crop scientists and researchers, need to be sensitive to such changes and respond far more quickly to *real-farm* issues. The argument is that scientific literacy and exchange of scientific information is one of the major imperatives in helping us cope with the constantly changing and uncertain crop production scenario.

While concluding I would like to mention here the guiding principles of future education set out by Cornish (1977):

- The future is not fixed, but consists of a variety of alternatives among which we can choose.
- Choice is necessary. Refusing to choose is itself a choice.
- Small changes through time can become major changes.
- The future world is likely to be different in many respects from the present world.
- People are responsible for their future; the future doesn't just happen to them.
- Methods successful in the past may not necessarily work in the future, due to changed circumstances.

Therefore, as a first step, we at ISS need to provide future-oriented platforms which essentially allow us to glean the extensive literature on spices and aromatic crops from which an appropriate selection of key researchable issues can be identified. Opportunities are many, so are the difficulties. Let us build on the strength of our past achievements to unfold the future because the future is the realm of dreams which can only be realized through collective effort.

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Genetic and varietal diversity in chilli and its conservation

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Chilli is the universal spice of India. Being an important commercial crop it finds diverse utilities as a spice, condiment, culinary supplement, medicine, vegetable and ornamental plant. It is cultivated in all the States and Union Territories of the country. The important States growing chilli are Andhra Pradesh, Orissa, Maharashtra, West Bengal, Karnataka, Rajasthan and Tamil Nadu. Andhra Pradesh alone commands 46% of the chilli production in India. As per the latest statistics, India is expected to produce 9.0 to 9.5 lakh tonnes of dry chilli during 2011-12. Chilli has two important commercial qualities. If some varieties are famous for red colour because of the pigment capsanthin, others are known for biting pungency attributed by capsaicin. India is the only country rich in many varieties with different quality factors.

The genus capsicum belongs to the family Solanaceae. It includes 22 wild species and three varieties as well as five domesticated species of the new world tropics and subtropics. In general domesticated species have larger but fewer fruits than their wild counterparts though seed per plant is about the same. The five major cultivated species are

- *Capsicum annuum*
- *C. frutescence*
- *C. chinense*
- *C. pendulum*
- *C. pubscense*

The pepper or capsicum breeding has evolved through the domestication of wild species in the Central and South America. The diversification of genotypes, subsequent establishment of the landraces and farmers selections have facilitated classical genetic and cytogenetic exploitation for improvement.

The genus *Capsicum* comprises all the varied forms of fleshy-fruited peppers grown as herbaceous annuals - the red, green, and yellow pepper rich in vitamins A and C that are used in seasoning and as a vegetable food. It includes paprika, chilli pepper, red pepper (cayenne), and bell peppers. The capsicums under each category vary tremendously and the species designation is not always possible. In general, paprika belongs to *C.annum* and the red peppers and chilli peppers belong to the *C. frutescens* species Among the capsicum species *C. annuum* is the one, which is the most commercially exploited. The domesticated *Capsicum* spp. can be grouped into two groups depending upon cross compatibility

1. The white flowered taxa which includes *C. annuum, C. chinense,* and *C. frutescens*
2. The purple flowered taxa consisting of *C. pubescens, C. eximium* and *C. cardenasii.*

C. annuum	↔	*C. chinense*
C. frutescens	↔	*C. chinense*
C. frutescens	↔	*C. pendulam*
C. annuum	→	*C. frutescens*
C. annuum	→	*C. pendulam*
C. chinense	→	*C. pendulam*
C. pubescens	→	*C. chinense*

The species *Capsicum annuum* includes most of the edible capsicums.

- The *capsicum annuum grossum* is a shrubby perennial, which seldom grows more than 18 inches high. Its fruit are large glossy green bell peppers mostly used in salads.
- The *Capsicum annuum acuminatum* is a slightly larger plant, also perennial, and it produces the thin conical twisted fruit that are dried and used for making various hot chilli powders.
- The *Capsicum annnuum longum*, or long chilli pepper, has a drooping, red or yellow fruit, 8-12 inches in length and is normally not very hot to eat.
- The *Capsicum annnuum concordes*, or cone chilli pepper, has erect and conical fruit, between 1 and 3 inches long, and very hot. Tabasco chilli as a good example of this species.
- The *Capsicum annnuum fingerh* is slim and pointed. It grows over 4 inches long, mainly in India and is used in the production of hot chilli powder.
- The *Capsicum frutescens* is mainly grown in the tropics, and can reach a height of 6 feet. This species produces blunt conical fruits, which are extremely hot and acrid, main used in the production of hot cayenne pepper.

The most potential varieties/ hybrids in major cereal crops were considered the main causes of green revolution. More than 30 per cent yield increase was attributed to improved genotypes alone. A similar scenario however does not exist in most vegetables and spices and chilli is not an exception. Open pollinated varieties have dominated the commercial chilli cultivation due to locally preferred specific trait. The research on chilli initially focused on development of high yielding chilli varieties suitable for wider adaptability. The varieties are quite familiar with the farmers, but their cultivation remains confined to the area of release. Many local varieties/ landraces are also under cultivation in different states.

The AVRDC pepper collection totals 6,835 accessions coming from 95 countries. The responsibility of the AVRDC Pepper Breeding Unit is to develop improved varieties that are suitable for dissemination throughout the tropics and sub-tropics via AVRDC links with national programs in Asia, Africa and Latin America. AVRDC also maintains links with advanced institutions in developed nations so that new technologies can be readily adopted to its own programs.

Various studies have been carried out in UAS, Dharwad to assess the genetic diversity, variability and improvement of chilli. The earlier studies conducted in chilli concentrated on genetic improvement and estimation of quality parameters (Khadi 1984), assessment of genetic diversity of germplasm material obtained from NBPGR (Shirshat 1994), purification of byadagi chillies with respect to the quality parameters (Giritammannavar 1995) and development of CMS based hybrids and their evaluation (Gaddagimath 1996 and Hiremath 1999).

Investigations were carried out to know the combining ability, heterosis and to study the path analysis and association of characters in chilli during kharif 2004-05. The study involved the evaluation of 40 hybrids along with 14 parents to assess combining ability of parents, estimation of heterosis over mid parent, better parent and standard check, and to understand the association of characters and to formulate selection criteria for improving green fruit yield. The hybrids SKAU-SC-965-5 × Arka Lohit (601.50 g), SKAU-SC-1003 × Arka Lohit (626 g) had highest mean values for green fruit yield. The parents Arka lohit, SKAU-SC-965- 5, GPC-82, SKAU-SC-1003 and SKAU-SC-304-1 were identified as good general combiners for fruit yield. The hybrids SKAU-SC-1005 x Kiran, SKAU-SC-1003 x Arka lohit SKAUSC- 965-5 x KIRAN, SKAU-SC-618-2 x GPC-82 and SKAU-SC-814-2 x GPC-82 were identified as good specific combiners for fruit yield per plant.

Lankesh Kumar and Sridevi (2005) assessed the magnitude of heterosis and combining ability in the line x tester cross material involving 72 hybrids and one standard check (Byadagi dabbi) The analysis of variance indicated significant amount of variability among the genotypes for all the 14 traits studied. Significant and standard heterosis in desirable direction was recorded by majority (30) of the crosses for fruit yield. Analysis of combining ability variance revealed that the SCA variance was higher than GCA variance indicating predominance of non-additivity for all the characters studied. Evaluation of parents for all the 14 traits studied indicated Byadagi dabbbi, Co-1, 124, G-3, KDC-1, Lokur local, AR-75, and S-32 are the good general combiners.

Savita and Sridevi (2006) conducted on to study to assess the magnitude of heterosis and to identify good general combiners for quality parameters and yield. The crosses Pant C-1 x Lokur local, 124 x Singanahalli local, Pant C-1 x VN-2, 124 x Byadagi dabbi and Punjab lal x KDC-1 had maximum standard heterosis for traits ascorbic acid, reducing sugar, total sugar, phenol and colour value respectively. The analysis of variance for combining ability indicated that mean sum of squares due to LxT interaction was highly significant for all characters. The SCA variance was higher than GCA variance for all characters indicating predominance of dominance variance. Evaluation of parents for all the traits studied indicated 124, Co-1, Pant C-1, S-32, AR-75, Punjab lal, K-3, Lokur local and VN-2 as good general combiners. The crosses S-32 x VN-2, Pant C-1 x Byadagi dabbi, Co-1 x Byadagi dabbi, Co-1 x Byadagi kaddi and G-4 x Singanahalli local were identified as the best specific combiners for all traits studied.

Srilakshmi and Mohan kumar (2006) took a study on chilli germplasm during kharif 2005, to estimate the extent of variability and diversity in the available 100-germplasm entries along with Byadgi Dabbi and Byadgi Kaddi. Considerable variability for most of the characters was indicated by analysis of variance. High phenotypic and genotypic coefficient of variation was observed for quality traits, fruits per plant and dry fruit weight. These characters are of economic importance and there is scope for improvement through selection. Genetic diversity in the available germplasm assessed by using D2 statistic, 102 genotypes were grouped into 15 clusters which had high range of inter cluster D2 values. Four characters viz., yield per plant, fruit diameter, number of fruits per plant and stalk length were the chief contributors towards genetic divergence. Hybridization of cluster XV with other clusters suggested as it was most divergent from other clusters. Genotypes DCA 147, DCA 57 for high fruit yield, DCA 97, DCA 111, DCA 66 for desirable fruit characters, DCA 111, DCA 43 for disease resistance along with Byadgi Dabbi for high colour value are identified as the most promising collections.

Vani and Sridevi (2006) conducted a study to access correlation morphological and molecular diversity in Chilli. Correlation study for yield per plant showed significant positive association with all growth related, yield related and fruit related traits. Plant height, fruit diameter, fruit surface area, pericarp weight showed negative direct effect while all other characters showed positive and high direct effect. The 55 genotypes were grouped into 14 clusters. Cluster XIV having IC-16 genotype showed maximum average mean value for plant height, fruits per plant and yield per plant. RAPD analysis with 20 random primers showed high polymorphism with primer OPJ-01 and OPJ-10. No correlation was observed between morphological and molecular diversity.

In vitro regeneration and Agrobacterium-mediated genetic transformation was studied in popular local cultivar of chilli *viz*., Byadagi Kaddi (Channappagoudar and Patil, 2007). Different explants (cotyledon, hypocotyls and cotyledonary nodal region) were cultured on MS medium supplemented with various levels of BAP (2–12 mg/l) and TDZ (0.1-1.0 mg/l) for adventitious shoot induction. Frequency of adventitious shoot induction was significantly more in cotyledonary nodal region explant than cotyledon and hypocotyls explants. Adventitious shoot induction response was high on medium with 0.5 mg/l TDZ. Addition of 1 mg/l of GA3 to this medium resulted in higher frequency of shoot elongation. The elongated shoots were rooted on MS medium with 0.5 mg/l IAA and 0.1 mg/l BAP.

Different concentrations and combinations of growth regulators were tried to study callus induction and regeneration from cotyledon, hypocotyls and cotyledonary nodal region explants. The media combination of 0.5 mg/l 2, 4-D and 0.5 mg/l kinetin resulted in higher quantity of callus. Elimination of 2, 4-D from this media induced somatic embryos. Complete regeneration was also observed on the same media but with very low frequency (10%).

Shoot apical meristems were co-cultivated with Agrobacterium strain EHA105 carrying pBinBt3 construct having cry1Ac gene. The explants pre-cultured for 48 hours, infected with agrobacterial suspension having 0.5 × 108 cells/ml for 10 min along with acetosyringene @ 200 μM for 48 hours yielded the transformants under in vitro conditions. Analysis of the putative transformants for the presence and expression of cry gene revealed that the transformation efficiency was 0.5 per cent. In two step RT-PCR amplicon of 1000 bp revealed the expression of transformed gene.

Dandunayaka and Rudra Naik (2008) conducted on experiment to assess the genetic variability and diversity in the available 60 germplasm collected from different parts of Northern Karnataka. These germplasm was evaluated for 12 quantitative characters and 6 quality characters. Considerable variability for most of the characters was indicated by analysis of variance. High phenotypic and genotypic co-efficient of variation was observed in yield related traits, fruit per plant and fruit weight. These characters are of economic importance and there is scope for improvement through selection. Sixty genotypes were grouped into 11 clusters which had high range of inter cluster D2 value. Five characters viz. secondary branches per plant, fruit colour, chlorophyll content, fruit diameter and days to 50 per cent flowering were the chief characters contributed towards diversity. Hybridization of cluster number III with cluster number IV is suggested as it was most divergent from other clusters. Genotypes like ACA-8, ACA-28, ACA-33 and ACA-40 are desirable for fruit yield, whereas ACA- 33, ACA-8, ACA-25 and ACA-26 are the desirable genotypes for export purpose.

Sandeep and Mohan Kumar (2008) carried out a study to access correlation and morphological and molecular diversity in Byadagi kaddi and Dabbi accessions. Correlation study in Byadgi kaddi accessions indicated significant positive association of dry fruit yield per plant with plant height, number of primary branches, number of secondary branches, fruit diameter and number of fruits per plants, whereas in Byadgi dabbi accessions, fruit yield showed correlation with plant height, number of primary branches, fruit diameter. Genotypic path for yield per plant revealed that fruit diameter, number of primary branches, seed weight per fruit and plant height had positive direct effect on yield in Byadgi kaddi and seed number per fruit, number of primary branches, number of secondary branches, fruit length had direct positive effect on yield in Byadgi dabbi. Genotypic path for yield through biochemical traits revealed high direct effect of non-reducing sugar in Byadgi chilli. Genetic diversity study resulted 18 clusters in Byadgi kaddi and 14 clusters in Byadgi dabbi. Number of seeds per fruit contributed maximum to the diversity. Out of twenty primers used OPJ01, OPJ10 and OPC13 showed highest per cent polymorphism. Highest diversity was observed between accession BD19 and BK21. Among twenty accessions each of Byadgi kaddi and Byadgi dabbi 89 per cent of similarity was observed.

Table 1. Important varieties cultivated in India

Sl. No.	Variety	States of cultivation	Important characters
1.	Guntur chilli S4 type	Andhra Pradesh	Pods are medium long with thin compressed base and pointed tip. High seed content, thin pericarp and colour of the fruit varies from light red to dark red. ASTA colour value – 32.11. Capsaicin – 0.226%
2.	Mundu type	Andhra Pradesh	Pods are short, 2-5 cm stout, oval, round fruits. Pericarp is thick with dark red colour, ASTA colour value – 43.12. Capsaicin – 0.10 to 0.15 %
3.	Sullurpet chilli	-do-	Pods are short, 3-4 cm with glossy and leathery pericarp
4.	Bhainsa chilli	-do-	Pods are thin medium long upto 6 cm. Pericarp colour is red. Mildly pungent
5.	Bhagyalaxmi (G 4)	-do-	Suitable for green and dry chillies having wide adaptability
6.	Andhra jyoti (G5)	-do-	Short and stout variety with 45% seed content. Pericarp is medium red
7.	Sindhur	-do-	Long and stout podded dual purpose variety. Mildly pungent
8.	Kiran	-do-	Suitable for rainfed areas. Pungent types with capsaicin content of 0.225%. Tolerant to thrips and mites.
9.	Bhaskar	-do-	An yellow anther variety grown for dry pods. Pungent types with high yield levels.
10.	Prakash	-do-	Prolific bright red colour variety. Highly pungent with medium long pods. Moderately tolerant to sucking pests,

			bacterial leaf spot and fruit rot. Widely adapted to all chilli growing areas of Andhra
11.	LCA 305	-do-	Bushly growth with long branches and yellow anthers. Moderately tolerant to sucking pests. Dual purpose chilli under ideal growing conditions.
12.	Tadapally – Long	-do-	Popular variety of Tadapally district of Andhra Pradesh. Fruits red in colour, tick skinned and less pungent. ASTA colour value – 80.30, Capsaicin – 0.11%
13.	Tomato chilli	-do-	Popular variety of the East and West Godavari districts, Warangal and Khammam. Variety is deep red and less pungent. ASTA colour value- 125.26. Capsaicin – 0.17%
14.	Kovilpatti 1 (K 1)	Tamil Nadu	Selection from Assam type. Plants are tall, spreading type with 'Samba' type long fruits. Fruits are 6.6 cm long with pointed tip. Capsiacin – 0.21%. ASTA colour value – 19.26%
15.	K 2	-do-	Selection from cross between Assam type and Sattur samba. Plants are tall with fruits about 7.3 cm having blunt tip. Capsaicin – 0.23% and ASTA colour value – 56.10
16.	MDU 1	-do-	Mutant variety of K1. Cluster bearing type with 2-9 fruits/ cluster. Fruits are 8cm long and red in colour. Capsaicin – 0.13 %
17.	Ramnad Mundu	-do-	Popular variety of Ramnad district in Tamil Nadu. Fruits yellowish red and pungent. Capsaicin – 0.166%, ASTA colour value – 32.95
18.	Sattur – S4	-do-	Popular variety of Sattur, Dindigul, Theni and Rajapalyam. Fruits are 7-8cm long, bright red, thick skinned and pungent. Capsaicin – 0.24% and ASTA colour value – 59.1
19.	Co-1	-do-	Selection from Sattur type. Suitable for cultivation in all three seasons through out the state. Fruits are medium long (8cm) with red colour and moderate pungency (Capsaicin - 0.30%).
20.	Madras Pari	Andhra Pradesh and Tamil Nadu	Grown in Nellore district of Andhra Pradesh and popularly available in Madras. Fruits are pure red in colour and hot. Capsaicin – 0.210% and ASTA colour value- 73.82
21.	Byadagi kaddi and dabbi	Karnataka	A popular variety of Dharwad and Haveri districts of Karnataka. It is highly branching type variety. Fruits attain deep red colour and wrinkles on maturity. Fruits are 15-18 cm long but less pungent. ASTA colour value – 156.9. Capsaicin – Negligible (0.073%)
22.	Sankeshwar	-do-	Plant grows to a height of 75cm. Fruits are 18to 20cm long, light green in colour, broad and pungent
23.	Chincholi	-do-	Plants are bushy in nature, ripe fruits are yellowish red in colour. It is highly pungent variety cultivated in the region of Gulburga, Bidar and Raichur districts.
24.	Mysore	-do-	Plants grow tall with few branches, Fruits are pungent and develop red colour with thick pericarp.

Genetic diversity and crop improvement in onion and garlic

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Alliums are among the cultivated plant species under family Alliaceae cultivated for food, medicines and religious purpose since early times. These crops are mostly strong flavoured due to presence of sulphur containing compounds responsible for distinctive smell and pungency (Robinowitch and Currah, 2002). Onion and garlic have bulbs and cloves, respectively as an underground storage organ, which are also used for vegetative propagation. Onion has primary centre of origin in Central Asia and secondary centre in the near East (McCollum, 1976). It occupies a vast area in Western Asia, extending from Palestine to India. Garlic has the central Asia as the primary centre and Mediterranean region as the secondary centre of origin (McCollum, 1976). It has long been grown in India and China. Onion is most commercial *Allium* grown worldwide over an area of 3.72 million hectare with 72.34 million tonnes of production. India is second largest producer of onion next to China. Country produces 13.9 million tonnes of onion from 0.84 million hectares of area and 10.7 lakh tons of garlic from 2.05 lakh hectares. Besides meeting domestic needs, India exports onion to the tune of 1.78 million tonnes worth Rs. 2243.12 crores. Maharashtra, Gujarat, Karnataka, Orissa, Uttar Pradesh, Madhya Pradesh, Rajasthan, Andhra Pradesh are major onion growing states (FAO Stat, 2009).

Onion is commodity of masses and used as salad and cooked in various ways in curies, fried, boiled, baked and used in soup making and pickles. Besides fresh consumption, onion provides very good raw material for processing industry as it is processed in the form of dehydrated powder, rings, shreds and onion in vinegar or brine. Onion as medicinal herb is known to ancient world, as it is mentioned in the medicinal treaties like "*Charak Samhita"*of third or fourth century A. D. (Ray *et. al.*1980a and 1980b). Sanskrit language equivalent signifying Vedic period and Aryan usage is available for onion as "*Palandu"*(Aiyar and Vaganarayana, 1956). The important principle like *allicin, ajoene, allixin thiosulfinates,* and *sulphites* etc. present in onion, make it potential herb. These components help fighting *cancer, high blood cholesterol* and *sugar, liver problems* and *intestinal* problems. Commonly cultivated *Alliums* are Common onion (*A. cepa* var. *cepa* L., 2n=16), Shallot (*A. cepa* var. *aggeregatum* G. Don., 2n=16), Welsh onion (*A. fistulosum* L., 2n=16), Chinese chives *(A. tuberosum* Rotti. Ex Spreng, 2n=32), Garlic (*A. sativum* L., 2n=16), Leek (*A. ampeloprasum* var. *porrum* (L.) J. Gay, 2n=32) and Chives (*A. schoenoprasum* L., 2n=16,24,32)

Genetic diversity

Onion show particular diversity in the eastern Mediterranean countries through Turkmenia and Tajikistan to Pakisthan and India, therefore these regions are most important sources of genetic diversity. The regions of high species diversity exist in Commonwealth of Independent States (CIS), Turkey, Iran, North Iraq, Afghanisthan, Pakistan and hilly tracts of North and North-Eastern India (Astley et al. (1982). According to the recent surveys, all taxa of the genus *Allium* cultivated in South-East Asia are introduced either from China, central Asia or Europe (Bujisen, 1990). Besides, wild species are generally restricted to the northern hemisphere and totally absent in tropical parts of South-East Asia. The species cultivated in South-East Asia which have their origin and secondary centre of diversity in Sino-Japanese centre, may include Welsh onion, Rakkyo, Chinese chives etc. The above species are also found in India gene centre, some of them still in the wild state. Zeven and Zhukovsky (1975) reported *Allium* species in different centres of diversity as in Chinese Japanese Centre consist of *A. chinense*, *A. fistulosum, A. sativum, A. schoenoprasum, A. tuberosum,* Hindustani Centre have *A. ampeloprasum* and Central Asia and Mediterranian region have *A. cepa* and *A. sativum*. Babu, 1977, reported that in India, the genus *Allium* is widely distributed in the temperate and alpine regions and about 30 species have been reported to occur in Indian gene centre. Negi and Pant (1992) reported the occurrence of lesser known wild species in mountainous regions and discussed information on their habitat, local uses, etc. The prominent wild species included in the study were *A. carolinianum* D.C. (syn. *A. bladum* Wall.), *A. chinense* G. Don (syn. *A. bakeri* Regel), *A. consanguineum* Kunth, *A. humile* Kunth (syn. *A. govanianum* Wall ex Baker), *A. przewalskianum* Regal (syn. *A. jacquemontii* Regel, *A. stolczkii* Regel), *A. steacheyi* Baker, *A. victorialis* L. and *A. wallichii* Kunth. According to Hooker (1973) the most widely cultivated *Allium* species in the Indian sub-continent include, onion, garlic, shallot and leek. Genetic diversity in cultivated alliums has been reported from different parts of the country. The prominent ares of genetic diversity are considered to be Jammu and Kashmir, Himachal Pradesh, Uttaranchal, North-East region, Rajesthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Meer and Vries (1990) reported transfer of downy mildew resistance from A. roylei to *Allium cepa*. Peterka et al., 2002 attempted transfer of male sterility including cytoplasm from onion to leek.

Domestication

Adoption of onion in India is carried through from very early times before Christian era. Originally, native of Central Asia of temperate region with perennial/ biennial habit and long day bulbing characters, it has established well in India under tropical and short day (11-11.5 hrs.) photoperiodic conditions (Sheshadri and Chaterjee, 1996). During acclimatization of different kinds of vegetable crops and their varieties, farmers applied selection pressure involuntarily to meet the market preferences. In case of onion, ability to produce seeds indigenously has played an important role in the adaptation. In course of adaptation and diversification, out breeding mechanisms present in onion has promoted selections suited to diverse environments.

In the centre of origin and area between35 to 40^0N latitude, onion is biennial in seed production and requires more than 14 hrs day lengths for bulb production. In subtropical and tropical parts of India between 12 to 25^0N latitude, it is biennial but able to produce bulbs under comparatively shorter photoperiod (11-11.5 hrs.) during winter season. Winter season crop accounts for 60 per cent of total production in the country. The concentration of onion growing in Western Maharashtra and Gujarat is very significant, where two crops – one in rainy season (*kharif*) and other in winter season (*rabi*) – are regularly grown. The tropicalization progresses further southwards towards Bellary region in Northern Karnataka and finally a vegetatively propagated multiplier onion (aggregatum) type got established in Tamil Nadu (6 – 8 ^{0}N latitude). The adoption to hardy conditions of high rainfall, high temperature and short day photoperiod typical of rainy (*kharif*) season of Western India has not been chronologically documented (Sheshadri & Chaterjee, 1996).

Export trade from Mumbai and Kandla port mainly to Gulf countries predominantly during November to April coincides with harvest of rainy seasons (*kharif*) and late rainy seasons (*Rangda*) crops. This is very typical example that market forces have influenced domestication and diversification to great extend. Demand for highly pungent and pink skinned bulbs from Gulf countries made farmers of Western India to select such type of plants, which can produce seeds under Indian conditions. This kind of adaptations made the crop plant to become annual. This phenomenon resulted in loss of short dormancy of bulbs. This fascinating aspect of onion domestication in Western India had gone unnoticed and unrecorded (Sheshadri and Chaterjee, 1996).

There has been spectacular increase in area and production of onion over last 20 years, however, the productivity has almost remained static i.e. 10-16 tonnes per hectare, which is much less as compared to USA, Netherlands, China, etc.

Onion varietal development in India

In India systematic breeding programme was started as early as 1960 at Niphad, Nashik and later on at IARI, New Delhi. The early varieties developed through selection were N 2-4-1; Pusa Red and N – 53 that are still dominating the production. The programme was further strengthened under coordinated project through SAUs and ICAR research institutes. As a result 55 varieties of onion including 2 F1 hybrids and 6 varieties of multiplier onion have been developed and released (Table.1). Onion is mainly *Rabi* season crop, but it can be cultivated in kharif and late kharif season also. Therefore varieties are recommended for different seasons. For kharif season, varieties suitable are Baswant – 780, N-53, Agrifound Dark Red, Arka Kalyan and Bhima Super, for late kharif: Baswant – 780, Bhima Red, Bhima Shakti, Phule Samarth, and Agrifound Light Red and for rabi season: N-2-4-1, Arka Niketan,Bhima Raj, Bhima Red, Bhima Kiran, Bhima Shakti, Agrifound Light Red, Pusa Red, Pusa Madhawi, etc. Bhima Raj can be cultivated in kharif and late kharif season also. There are white coloured varieties which can be grown during rabi season are Phule Safed, Pusa White Round, Pusa White Flat, Bhima Sweta, Agrifound White, Punjab Selection, Udaipur – 102 and Bhima Shubra for kharif season. List of varieties released from various research institutes/ universities in India are as follows:

Table1. Varieties of onion developed by different organizations

S.No.	Organization	Onion variety	Colour of bulb
1.	Agril. Dept., M.S.	N-2-4-1	Red
		N-53	Red
		N-257-9-1	White
2.	M.P.K.V., Rahuri	Baswant-780	Red
		Phule Safed	White
		Phule Swarna	Yellow
		Phule Samarth	Red
3.	IARI, N. Delhi	Pusa Red	Red
		Pusa White Flat	White
		Pusa White Round	White
		Pusa Ratnar	Red
		Pusa Madhavi	Red
		Early Grano	Yellow
		Brown Spanish (Long day)	Brown
4.	IIHR, Bangalore	Arka Niketan	Red
		Arka Kalyan	Red
		Arka Bindu	Red
		Arka Pragati	Red
		Arka Pitambar	Yellow
		Arka Lalima (F1 hybrid)	Red
		Arka Kirtiman (F1 hybrid)	Red
5.	HAU, Hissar	Hissar 2	Red
		HOS-1	Red
6.	NHRDF, Nashik	Agrifound Dark Red	Red
		Agrifounf Light Red	Red
		Agrifound White	White
		Agrifound Rose	Red
		Agrifound Red (Multiplier)	Red
		L-28	Red
		Line-355	Red
7.	VPKAS, Almora	VL-1 (Long day)	Red
		VL-3 (Long day)	Red
8.	RAU, Rajasthan	Udaipur 101	Red
		Udaipur 102	White
		Udaipur 103	Red
9.	CSAUAT, Kanpur	Kalyanpur Red Round	Red

10.	PAU, Ludhiana	Punjab Selection	Red
		Punjab Red Round	Red
		Punjab Naroya	Red
		Punjab-48	White
		Punjab White	White
11.	TNAU, Coimbatore	CO-1, (Multiplier)	Red
		CO-2	Red
		CO-3	Red
		CO-4	Red
		MDU-1	Red
12.	RARS, Durgapura	Rajasthan Onion -1	Red
		Aprita (RO-59)	Red
13.	PDKV, Akola	Akola White	White
14.	DOGR, Rajgurunagar	Bhima Raj	Red
		Bhima Super	Red
		Bhima Red	Red
		Bhima Shakti	Red
		Bhima Kiran	Red
		Bhima Sweta	White
		Bhima Shubra	White

In India, the varieties developed by various organizations have been tested at different locations under All India Coordinated Vegetable Improvement Project and All India Network Research Project on Onion & Garlic and based on their performance these varieties have been recommended for different zones. So far 22 varieties have been recommended for cultivation under specific agro-climatic zones (Table 2).

Table 2. Onion varieties recommended for cultivation and release through AICRP

Sl. No.	Variety	Organization	Recommended zones	Year of identification
1	Punjab Selection	PAU, Ludhiana	IV, VII & VIII	1975
2	Pusa Red	IARI, N. Delhi	IV, VII, VIII	1975
3	Pusa Ratnar	IARI, N. Delhi	IV & VI	1975
4	S-131	IARI, N. Delhi	-	1977
5	N-257-9-1	Agril. Dept., M.S.	-	1985
6	N-2-4-1	Agril. Dept., M.S.	-	1985
7	Line-102	IARI, N. Delhi	I, IV, VI, VII	1987
8	Arka Kalyan	IIHR, Bangalore	IV, VI, VII, VIII	1987
9	Arka Niketan	IIHR, Bangalore	IV,VII, VIII	1987
10	Agrifound Dark Red	NHRDF, Nashik	IV	1987
11	VL-3	VPKAS, Almora	I	1990
12	Agrifound Light Red	NHRDF, Nashik	VI, VIII	1993
13	Punjab Red Round	PAU, Ludhiana	IV	1993
14	PBR-5	PAU, Ludhiana	VI	1997
15	L-28	NHRDF, Nashik	IV & VII	2006
16	HOS-1	HAU, Hissar	VI	2006
17	Bhima Raj	NRCOG, Rajgurunagar	VI	2007
18	Bhima Red	DOGR, Rajgurunagar	VII	2009

19	PKV White	PDKV, Akola	VI	2009
20	RHOR-S1(Phule Samarth	MPKV, Rahuri	VI, VIII	2009
21	Bhima Kiran	DOGR, Rajgurunagar	III & VI*	2010
22	Line-355	NHRDF, Nashik	III, IV & VI*	2010
23	Bhima Shakti	DOGR, Rajgurunagar	III, IV, V, VI*	2011
24	Bhima Sweta	DOGR, Rajgurunagar	III, V, VI*	2011
25	Sel-126	IARI, N. Delhi	III, IV, V*	2011

Details of the Zones under AICRP Vegetables:

Zone I= Himachal Pradesh & U.P. Hills, Zone II=West Bengal & Assam, Zone III=Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunachal Pradesh and Andaman & Nicobar Islands, Zone IV=Punjab, Tarai region of U.P. & Bihar, Zone V=Chhattisgarh, Orissa & Andhra Pradesh, Zone VI= Rajesthan, Gujarat, Haryana & Delhi, Zone VII= Madhya Pradesh & Maharashtra, Zone VIII= Karnataka, Tamil Nadu & Kerala

* New zones were decided during 2010 under AINRPOG: Zone III=Delhi, UP, Haryana, Bihar and Punjab, Zone IV=Rajasthan & Gujarat, Zone V=MP, Chhattisgarh & Orissa, Zone VI=Maharashtra, Karnataka and Andhra Pradesh

The improvement of onion crop has not attracted much attention of the breeders in India. Perhaps, because of biennial habit of the crop requiring longer time for breeding and difficulties in attaining and maintaining genetic uniformity due to high degree of natural cross pollination and rapid inbreeding depression. Though, number of varieties have been developed in India, still there is enough scope to develop varieties with high total soluble solids suitable for dehydration, short day yellow varieties for export and varieties resistant to diseases and insect pests and suitability to different seasons.

Baring few exceptions, the breeder stock of many varieties are not being maintained properly. Some of them never reached to farmers. However, few varieties always remained on the forefront. Despite release of high number of varieties, area under them is not more than 30 per cent. Remaining area is covered with the types maintained by the farmers themselves. Easier seed production for home requirement, at farmers' site is the main hurdle for spread of improved varieties. Non-availability of sufficient seed at reasonable price is the secondary one and finally, probably farmers have not overcome the presumption that all new varieties are *on par* with their material being maintained traditionally. All varieties developed so far and local types maintained by farmers suffer from all disease and pest, high percentage of twins, bolters and multi-centered bulbs and minor variations in colour, shape and maturity.

The improvement of onion crop has not received any attraction of the breeders in India. Perhaps, it is because of biennial habit of the crop requiring longer time for breeding and difficulties in attaining and maintaining genetic uniformity due to high nature cross pollination and rapid inbreeding depression. Besides, lack of facilities for storage of selected bulbs of breeding lines in controlled storage conditions is another factor for slow progress in onion breeding programme (Swarup, 1990).

Methods adopted for population improvement in onion

Being cross – pollinated, onion always provides a scope for using new population improvement methods, as natural variability is created constantly. Tremendous amount of variability is being utilised in onion using various breeding procedures. Different gene actions and gene combinations identified by genetic studies are being employed for generating new varieties and developing material for making new hybrids. Information on the nature and extent of genetic variability and degree of transmission of traits is of paramount importance in enhancing the efficiency of selection. However, knowledge of correlations among various characters and their relative contribution to yield is useful for multiple trait selection.

Worldwide different group of scientists are inventing the new techniques for population improvement in onion utilizing conventional and new techniques for developing varieties and hybrids suitable for different purposes (Table 3).

Table 3. List of different onion varieties released worldwide using population improvement methods

	Variety released	Improvement method used	Scientists involved/ references
1	Improvement of ancient Russian variety 'Spasskii'	Mass selection and Intravarietal recurrent hybridization	Efimochkina, O. P. 1970
2	Yalova 1, Yalova 3 and Yalova 12	Mass selection in Marmara population and Single plant selection in Thrace population.	Akgun, H. 1970
3	N – 53	Mass Selection (Collection from Nashik, Maharashtra)	MPKV, Rahuri, 1975
4	Punjab Selection	Mass Selection in indigenous material (Collection from Punjab)	PAU, Ludhiana, 1975
5	Pusa White Flat	Mass Selection (Local Collection)	IARI, New Delhi, 1975
6	Pusa White Round	Mass Selection Local collection (106)	IARI, New Delhi, 1975
7	Co 2	Mass Selection (Collection from Tamil Nadu)	TNAU, Coimbatore, 1978
8	Punjab – 48	Mass Selection (Collection from Punjab)	PAU, Ludhiana, 1978
9	Pusa Ratnar	Mass Selection (Selection from Red Granex from USA)	IARI, New Delhi, 1978
10	Pusa Red	Mass Selection (Local Collection)	IARI, New Delhi, 1978
11	Co 3	Mass Selection (Collection from Tamil Nadu)	TNAU, Coimbatore, 1982
12	Kalyanpur Red Round	Mass Selection (Collection from U P)	CSUAT, Kanpur, 1983
13	Arka Pragati	Mass Selection (Collection from Nashik, Maharashtra)	IIHR, Bangalore, 1984
14	N – 2 – 4 – 1	Mass Selection (Collection from Pune, Maharashtra)	MPKV, Rahuri, 1985
15	Arka Niketan	Mass Selection (Mass selection from a local collection IIHR – 153)	IIHR, Bangalore, 1987
16	Agrifound Dark Red	Mass Selection (Collection from Nashik, Maharashtra)	NHRDF, Nashik, 1987
17	Pusa Madhavi	Mass Selection (Collection from Muzaffarnagar, U P)	IARI, New Delhi, 1987
18	'Dorata di Parma' resistant for *F. oxysporum* f. sp. cepae Snyd. et Hans.	Mass and recurrent selection	Fantino, M.G. and Schiavi, M., 1987, Italy
19	Arka Kalyan (Sel-14)	Mass Selection (Mass selection from a local collection IIHR – 145)	IIHR, Bangalore, 1987
20	Baswant – 780	Mass Selection (Collection from Pimpalgaon, Maharashtra)	MPKV, Rahuri, 1989
21	'VL Piaz 3'	3 cycles of Mass selection after F_2 of cross 'In-13 x L-43'	Mani V. P., Chauhan V. S., Joshi H. C., Tandon J. P., 1999
22	Screening and analysis of components of white shaft weight	Maternal pedigree selection in male sterile-plants and male-fertile plants (MPSMS and MPSMF)	Zhaoshui , L. *et al.*, 1995, Japan
23	'Composto IPA-6' and 'Belem IPA-9'	Breeding program tolerant to *C. gloeosporioides* and *T. tabaci*, good post-harvesting conservation qualities	De Franca, J.G.E and Candeia, J.A., 1997. IPA , Pernambuco, Brazil

24	Cobriza INTA	Mass Selection from Valenciana type onions	Galmarini, C.R., *et al.* 2001, Argentina
25	Navideña INTA	Mass Selection from Torrentina local population	Galmarini, C.R., *et al.* 2001, Argentina
26	Antártica INTA	Mass Selection from Valenciana type onions	Galmarini, C.R., *et al.* 2001, Argentina
27	NuMex Chaco' Onion	Recurrent Selection	Cramer, C. S. and Corgan, J. N., Las Cruces, New Mexico, 2001a
28	NuMex Snowball' Onion	Recurrent Selection	Cramer, C. S. and Corgan, J. N., Las Cruces, New Mexico, 2001b
29	NuMex Arthur' Onion	Recurrent Selection	Wall, M. and Corgan, J. N., Las Cruces, New Mexico, 2002
30	Congregation of desirable genes in Gholy – Ghesseh Local Onion	Mass Selection	*Lameie Heravani, Javad et. al.,*2004, Kheir-Abad Agricultural Research Center, Zanjan, Iran
31	Purifying the popular land variety "Abu Ferewa"	Phenotypic recurrent mass selection and Inbreeding followed by bulking	Bakheet, K. A. 2008
32	Genetic analysis in six generations (P1, P2, F1, F2, B1 and B2) of four onion crosses *viz*., PBR 138 x AN 187, PBR 139 x AN 184, PBR 139 x AP 195 and PBR 140 x AN 184	Reciprocal recurrent selection: Exploit all gene actions simultaneously to develop a new resistant line/ variety, being best method to improve trait of resistance to purple blotch disease.	Evoor, S. *et al.,* 2007, Karnataka, India
33	Arka Pitambhar	Pedigree selection from the cross U.D. 102 x IIHR-396	IIHR, Bangalore http://www.iihr.res.in/frmVarities.aspx
34	Bhima Super	Rigorous mass selection for single centeredness & bulb shape	Lawande *et al*., 2007
35	Bhima Red & Bhima Raj	Single bulb selection up to three generations followed by mass selection	Lawande *et al*., 2009
36	Bhima Shakti & Bhima Kiran	Mass selectionfor late kharif and rabi season with better storability & mass selection for rabi with good keeping quality	Lawande *et al*., 2010a & b
37	Bhima Sweta	Selection of elite lines from germplasm followed by random matting and mass selection for rabi season white onion	Mahajan *et al*., 2010
38	Bhima Shubra	Selection of white segregating bulb from red germplasm followed by mass selection for white populations for kharif & late kharif season	Mahajan *et al*., 2010

Mass selection and combinations of other methods

A number of experiments have been reported on inheritance of yield and maturity, many of which were concerned with the estimation of combining ability in various populations. In general, diallel crossing designs have been used for this type of estimation. A number of workers have reported both

General Combining Ability (GCA) and Specific Combining Ability (SCA) estimates for various parental lines; accounts are given by Hosfield and co-workers of diallel crosses of maximum of 10 inbred lines grown in trials over multiple seasons and sites in U. S. In which they measured 8 characters including yield and maturity. (Hosfield *et. al.,* 1975; Hosfield *et. al.,* 1977a and Hosfield *et. al.,* 1977b). There were highly significant GCA effects for both these characters and some evidences for relatively smaller significant SCA effects. Joshi and Tandon, in a set of crosses between male sterile and pollinator lines, demonstrated significant GCA effects for yield in the male sterile lines with evidence of SCA for one particular cross. (Joshi and Tandon, 1976).

A major contribution to onion breeding has been the development of new open pollinated (OP) varieties using a range of population improvement methods. OP varieties are defined as genetically variable populations, which are maintained and multiplied by mass pollination in isolation. The simplest one being mass selection, starting with a chosen parent population, the best approximately 1 to 5 % of mother bulbs of the desired type are selected at harvest or following storage and subsequently replanted to produce flowering plants which are mass pollinated together in isolation. Several cycles of mass selection are usually employed before larger scale multiplication of selected improved population to produce a new variety. Success depends upon presence of the required genetic variability in present population on which selection can operate. A refinement to mass selection is stratified mass selection, whereby the field plot of bulbs grown for selection is subdivided into equal sized areas and same proportion of selected bulbs of desired types chosen from each area. It helps to make allowance for the effect of variable growing conditions within the field plot on appearance of the mother bulbs and correspondingly to increase the chance of picking out heritable variation during the selection process (Brewster and Robinowitch, 1990).

Akgun, 1970 developed three varieties with spherical bulbs, yellow skins and white flesh through mass selection in the variable population of Marmara and single plant selection in that of Thrace. Yalova 1, with 15%, Yalova 3, with 10% and Yalova 12, with 16.5% of dry matter. Yalova 3 can be multiplied from seed, while the other two are propagated from sets and bulbs. Efimochkina, O. N., 1970 improved Spasskii, an ancient Russian variety, originating from the Spasskii District of Ryazan Province for the commercial quality, yield, ability to mature, firmness and keeping quality practicing mass selection and intravarietal recurrent hybridisation. A genetical analysis of cross between a Japanese Autumn sown X European Spring sown onion was undertaken by DeSouza (1985) using sophisticated triple test cross design. Early growth, maturity, yields per unit area, bulb weight, size, shape and quality characters were examined and in all characters evidence of significant additive genetic variance was found.

Arka Kalyan (Sel-14) was developed in 1987 through vigorous mass selection from IIHR 145 Globe shaped bulbs with medium large size. Deep red coloured outer scales and fleshy succulent internal scales. Average bulb weight 130-180g. It is pungent with TSS 11-13%, moderately resistant to purple blotch caused by *Alternaria porii* Seed yield 8 quintals/ha and is suitable for *Kharif* season. It has a duration 140 days and yield of 47 t/ ha.

In Italy, Fantino *et. al.*, 1987 intimated the use of mass and recurrent selection for develop the resistant lines for *F. oxysporum* f. sp. cepae Snyd. et Hans., as it is main Onion disease and causes serious damages both in the field and during the storage period. Cultivar "Dorata di Parma" was used for enhancing bulb traits and tolerance to *Fusarium* in 1975 using mass selection on naturally infected soil and three systems of recurrent selection (half-sib, S sub(1) and S sub(2)) on naturally infected soil and by means of artificial infection. The selected populations showed a percentage of rotten bulbs twice lower than that of the commercial populations of "Dorata di Parma", and similar to the medium tolerant hybrids Cosmic and CMW 745. Sudanese onion types and landraces have developed a high frequency of heterozygosity and heterogeneity and exhibit a wide genetic variability in many traits as they were been intercrossed with various introductions from Egypt, USA and West Africa, as well as between themselves. Hudeiba Research Station in northern Sudan, using the local germplasm, released three varieties for different purposes in 1987. Similarly, Nazareth Horticultural Research Station, Ethiopia developed commercially viable seed-grown varieties which were being used locally and exported using the Sudanese germplasm during 1970s and 1980s. (Mohamedali, 1995).

In 1995 genetical studies, carried out by Singh, additive gene effects for dry matter content, bulb size and maturity and additive and non-additive gene effects for bulb yield and number of leaves per plant were found to play important role. In India efforts are being made to develop purple blotch resistant varieties, but so far no durable resistant variety is available. However Selections 11–1–1 and IIHR-25 are reported to be resistant, from IIHR, Bangalore and Punjab Red Round and Punjab Narroya (PBR-5) are reported from PAU and tolerant to purple blotch (Singh, D., 1997). IPA - Empresa Pernambucana de Pesquisa Agropecuária, based at state of Pernambuco, Brazil released short-day yellow cultivars tolerant to *C. gloeosporioides* and *T. tabaci*, associated to good post-harvesting conservation, 'Composto IPA-6'. Again, 'Belem IPA-9' was released, having as main characteristics like good yield performance, adaptation throughout the year, and a remarkable tolerance to *C. gloeosporioides* (De Franca, 1997). Mani *et. al.,* in 1999 used mass selection, for exploiting general gene effect and additive x additive type of gene interaction in a cross combination 'In-13 x L-43'. Three cycles of mass selection of the F2 of this combination led to the development of an improved high yielding onion strain 'VL 3'. This high yielding open pollinated variety, designated as 'VL Piaz 3' was identified by All India Vegetable Improvement workshop during 1990 for hills and plains of U.P.

La Consulta Experiment Station, Argentina, released three cultivars namely Cobriza INTA, Navideña INTA, and Antártica INTA (Galmarini, 2001) aiming the goals of earliness and good storage quality in long-day cultivars, introduction of pink-root resistance and high dry matter into cultivars for the dehydration industry. Cobriza INTA was a selection from Valenciana type onions. The yield was similar to Valcatorce INTA; cultivar that covers most of the area in Argentina, but with greater bulb quality. Navideña INTA was selected from a Torrentina local population; and was an intermediate adapted cultivar with brown bulbs with three colored scales, and low pungency and Antártica INTA was a long day cultivar, obtained by selection from Valenciana type onions with white round bulbs, 14 % soluble solids, and good keeping quality.

In research carried out at Kheir-Abad Agricultural Research Center, Zanjan, Iran, mass selection method was used in order to congregate the desirable genes in local onion population of Gholy - Ghesseh in 1998-2002 (Javad, 2004). Initially single bulbs were selected based on bulb characters like (bulb weight, bulb diameter, bulb height, bulb neck, total biomass, bulb performance, and per cent of sprouting bulbs) number of flowering stems number of leaves, leaf weight, plant weight, dry matter %, during storage period. But presence of significant negative genetic correlation between double bulbing and neck bulb- being important economic characters of onion- confirmed the idea that simultaneous mass selection of these two characters is not efficient in onion breeding.

Tiemens-Hulscher et. al. (2006) did experiment for searching the onion varieties which are better adapted to organic farming. Two organic onion farmers and one conventional onion breeder were asked to follow positive mass selection method in three segregating populations under organic conditions. Selection in the field for earliness and downy mildew and after storage characteristics was followed. Farmers and breeder also applied identical selection directions for bulb traits as a round shape, better hardness and skin firmness. Resultant bulbs were bigger than in the original population. Bakheet, 2008 adopted two breeding methods, phenotypic recurrent mass selection and inbreeding followed by bulking for purifying the popular land variety "Abu Ferewa" selecting for high yield, high dry matter content in addition to uniformity of colour, shape and size and against doubling and premature bolting with good storability at ambient condition at Shambat Research Station, Khartoum North Sudan, during 2004/05 through 2006/07 seasons.

Bhima Super was developed by rigorous mass selection for single centeredness up to 7 generations and able to achieve more than 95% single centred bulbs with uniform desirable shape of bulb in India for kharif season (Lawande *et al*., 2007). Bhima Red and Bhima Raj were developed by single bulb selection up to three generations from B-780 followed by mass selection (Lawande *et al*., 2007, 2009). Bhima Shakti (Red) and Bhima Kiran (Light red) were developed through mass selection for late kharif and rabi and rabi season, respectively along with good keeping quality by Lawande *et al.,* 2010. Bhima Sweta a white onion variety suitable for rabi season was developed by selecting white onion elite lines from germplasm followed by random matting and further mass selection for three generation by

Mahajan *et al*., 2010. Bhima Shubra variety is suitable for Kharif and late kharif season in Maharashtra was developed by selecting white segregating bulbs from red onion germplasm line which was further purified and developed through mass selection (Mahajan *et al.*, 2010).

Family selection

More sophisticated Open pollination breeding schemes are based on family selection. Many of desirable agronomic characters are quantitative in nature and heritabilities are based on the individuals are low. In these circumstances, using family mean performance, rather than individual bulb as unit of selection can operate more efficient selection scheme. Commonly half-sib families or one and two generation selfed families are used. Number of families selected and number of cycles of selection is not necessarily fixed. New promising lines may be brought in the schemes at any stage of selection. The schemes operate at the alternate field evaluation of bulbs and controlled seeding of selection in consecutive seasons. Both the intermediate "improved" population and final variety created by intercrossing of selected bulbs from selected families by mass pollination in isolation are useful. The final variety may be maintained by mass selection in subsequent generations. Continuously population improvement methods are being used for development of the cultivars for various purposes. Wall *et. al*., 1996, used half-sib family analysis and selection response to estimate heritability of the pungency and single center in onion breeding populations.

Recurrent selection

Population improvement methods were applied to the spring-sown bulb onion crop. Partially inbred populations were also developed from synthetic populations, by half-sib selection methods. Synthetic populations were developed by recurrent selection based on selection of inbred lines by their *per se* performance for improved yield, bulb quality and storage performance (Dowker *et. al.,* 1984*).* Cramer, 2001a and 2001b and Wall, 2002 released two and one cultivars, respectively with different aims in different areas using recurrent selection method of population improvement. These are NuMex Arthur' Onion: low-pungency, high yielding, pink-root-resistant, intermediate-day, open-pollinated, yellow onion cultivar for spring seeding or transplanting in southern New Mexico. This cultivar was ideal for fresh market onion consumption. NuMex Chaco' Onion: single-centered, bolting-resistant, pink-root-resistant, early maturing, short-day, yellow onion cultivar for fall seeding in southern New Mexico. It was found that 'NuMex Chaco' produces a higher percentage of single-centered bulbs than any other fall-planted cultivar grown in southern New Mexico and is highly suited for onion ring processing and NuMex Snowball' Onion: late-maturing, pinkroot-resistant, round, hard, intermediate-day, white-colored onion cultivar for spring seeding in southern New Mexico and similar environments.

Reciprocal recurrent selection

Reciprocal recurrent selection breeding method was suggested by Evoor *et. al.*, in 2007, to exploit all the gene actions simultaneously to develop a new resistant line/ variety, as it is the best method to improve trait of resistance to purple blotch disease. Genetic analysis in six generations (P1, P2, F1, F2, B1 and B2) of four onion crosses viz., PBR 138 x AN 187, PBR 139 x AN 184, PBR 139 x AP 195 and PBR 140 x AN 184 to study the inheritance of resistance to purple blotch disease both under natural epiphytotic condition and artificial inoculation method, revealed that both additive (d and i) and non-additive (h, j and l) gene action were significantly operative in all the crosses. However, the interaction dominance x dominance and dominance type of gene action was predominant. Duplicate type of epistasis was observed in all crosses.

Pedigree selection

Zhaoshui (1995) conducted two cycles of maternal pedigree selection in male sterile-plants (MPSMS) and maternal pedigree selection in male fertile plants (MPSMF) in a local variety. Progressive regression and path coefficient with three replications was used for the screening and analysis of components of white shaft weight. The results showed the difference in components of white shaft weight in MPSMS and that of MPSMF. In green onion breeding for high weight of white shaft, increasing white shaft length was found to be the best selection criterion in MPSMS, whereas it was white shaft diameter in case of MPSMF. IIHR, Bangalore, developed Arka Pitambar through pedigree selection from the cross U.D. 102 x IIHR-396, with Medium size (5.2-6.0cm) bulbs having globe shape and thin neck. Mild pungency with TSS 11% and total sugar 9.81%. It was also tolerant to purple blotch, basal rot diseases and thrips.

Need for development of varieties in India

So many varieties were developed in India but restricted to rabi season and only yield only. Besides lot of germplasm available in India still one is compelled to ask questions as (i) have the available variability and yield potential of tropical short day types exploited fully? (ii) If so, should we continue for searching germplasm for still new varieties? (iii) If not, what should be the breeding strategy for further exploitation?

Breeding for seasonal adaptability

Commercial onion in India is planted between 12 to 25^0 N latitude during following seasons (Table 4).

Table 4: Seasonal variations in different states

Sr. No.	Season	Time of sowing	Time of transplanting	Time of harvesting
A.	Maharashtra and some parts of Gujarat			
	1. Kharif 2. Early rabi or late Kharif 3. Rabi	May-June August-Sept. Nov.-Dec.	July-August Sept.-October Dec.-January	October-December January-March April-June
B.	Tamil Nadu, Karnataka and Andhra Pradesh			
	1. Early Kharif 2. Kharif 3. Rabi	April-May May-June Sept.-Oct.	May-June July-August Nov.-Dec.	August October-Nov. March-April
C.	Rajasthan, U.P., Haryana, Bihar, Punjab, West Bengal and Orissa			
	1.Kharif 2.Rabi	May-June Oct.-Nov.	July-August Dec.-January	Nov.-December May-June
D.	Hills			
	1. Rabi 2. Summer (long day type)	Sept.-Oct. Nov.-Dec.	Oct.-Nov. Feb.-March	June-July August-October

Kharif crop is grown during hot and humid months and ready for harvest when temperatures are low. The bulbs do not become mature as growth continues due to shorter days and cooler temperature. The bulbs of Kharif season do not have good storability. Although, the day length during this period is slightly more than rabi, the critical value of day length available is around 11-11.5 hrs due to cloudy weather. Through centuries of selection the types, which can respond to warm and humid days with 11-11.5 hrs, have been identified and maintained by farmers. From the same material superior genotypes like

N-53, Agrifound Dark Red, Basawant 780, Bhima Super, Bhima Shubra and Arka Kalyan have been developed.

Recently due to late monsoon or irregularities of rain in Kharif season there has been shift in planting from Kharif to late Kharif. Availability of irrigation water from September to February, failure of Kharif crop due to high rainfall coupled with high incidence of diseases and pest and poor storage of Kharif produce, farmers in Western Maharashtra are inclining towards late Kharif crop commonly called as Rangda onion. Seedlings are transplanted in September-October and bulbs are ready for harvest in January-February. Low temperature during November -December favours bulb initiation and good development. Warm days during January-February facilitate maturity, as the day length available is again 11-11.5 hrs. The yields are high with good bulb size but percentage of bolting and twins is very high and therefore reduce marketable yield. Further, storability of bulbs is also low as compared to rabi produce. Some of the varieties like Bhima Shakti and Bhima Shubra developed by DOGR and Phule Samarth developed by MPKV, Rahuri was recently recommended for late kharif season. Still there is need to intensify research work in India for different location for late kharif season for early arrivals in market.

In case of winter (rabi) crop seedlings are transplanted in November-December, low temperatures (20-25^0 C) during December-January favour bulb initiation under again short day conditions i.e. 11-11.5 hrs. Bulb growth and maturity is in February and March where nights are cool and days are warm (35-40^{0}C). High temperatures during April-May hasten maturity. There is better curing of neck and such bulbs store well up to 5-6 months. Bulb quality is good. Almost all genotypes grown in this season are of light red coloured. But now a day demand is changing towards dark red onions during rabi season also. Hence there is need to develop dark red onion varieties with good storage during rabi. Bhima Shakti is among these recently recommended having dark red bulbs with good keeping quality during rabi season.

In India pink skinned and pungent types are preferred essentially for cooking, due to its strong flavour. In contrast for salad, yellow skinned and sweet onion varieties of western countries are not liked in India and hence long day onions do not find flavour. Incidentally, high productivity in western countries is favoured by long maturity season and long day photoperiodic conditions, which in turn promote high quality (high TSS) and very compact bulbs. Tropical onions maturing under short day conditions and short growing season yield less with somewhat poor quality bulbs. Hence, Indian average is only 10-12 tonnes/ha against 30 tonnes in countries located between 25 to 30^{0}N latitude (Sheshadri and Chaterjee, 1996).

Staggered planting in different seasons warrantee for steady supply of onion in the country. Unfortunately there is limited Varietal wealth for Kharif and late Kharif season. Early maturity, dark red colour and resistance to colletotrichum and purple blotch is the need of Kharif season. Further, the varieties need some dormancy for effective marketing. Recommended varieties like N-53, Basawant 780, Arka Kalyan, Agrifound Dark Red and Phule Samarth suffer from these drawbacks. Late Kharif season is becoming more popular in Maharashtra due to high yield and less hazards of diseases and pests. High percentages of bolting and poor storage are the limited factors. There is no suitable variety in dark red as well light red colour at the time of marketing or export is the requirement. Some light red coloured varieties meet the standards; however there is need to develop dark red coloured varieties for rabi season also.

Breeding for processing qualities

Dehydrated products such as flakes, rings, granules, powder etc. and processed onion as onion in vinegar and brine are the important byproducts being prepared and marketed world wide. Processing industries in any commodity play an important role in stabilizing prices in domestic markets. Dehydration industries demand for white onion varieties with globose shape pf bulb and high TSS (>18%). All Indian white onion genotypes are having TSS range between 11-13%. Model variety for dehydration should be pure white, with globose shape, thin neck, free from greening and moulds, high pungency and high T.S.S. The variety should be high yielding with field tolerance/resistance to diseases and pests. Wider seasonal adaptability is also an important character from continuous supply point of view. T.S.S. and pungency is a function of genotype, cultural practices and environment. Indian varieties are short day type mature within 90-120 days. They are basically low T.S.S. varieties. The T.S.S. varies from 10 to 14% in Indian material. Some of the long day varieties which mature within 150-180 days offer high T.S.S. range from 15 to 24%. But long day varieties do-not produce bulbs under Indian short day conditions. However, intermediate short day varieties produce good bulbs but seed production is not possible under plains. In plains of India varieties mature in high temperature, which facilitates high sulphur built up and therefore Indian varieties are more pungent. In India attempts were made for development of white onion varieties by different research institutes. The details are given in Table 5.

Table 5: Performance of white onion varieties developed in India

Sl. No.	Name of variety	Source	T.S.S. %	Average yield q/ha
1.	Pusa White Round	IARI, New Delhi	11.13	300 – 325
2.	Pusa White Flat	IARI, New Delhi	10.00	325 – 350
3.	Udaipur 102	RAU, Udaipur	10.06	300 – 350
4.	Agrifound White	NHRDF, Nashik	10.76	200 – 250
5.	Phule Safed	MPKV, Rahuri	10.13	250 – 300
6.	PKV White	PDKV, Akola	09.55	250 – 300
7.	Gujarat White	JAU, Junagadh	-	300 – 325
8.	N-257-9-1	Agril. Deptt., M.S.	10.00	250 – 300
9.	Punjab-48	PAU, Ludhiana	11.00	300 – 325
10.	V-12	Jain Food Park	15.00	350 – 400
11.	Nimar Local	Land Race, M.P.	12.50	250 – 300
12.	Talaja Local	Land Race Bhavnagar	12.00	250 - 300

After assessing Indian varieties and land races which do-not offer T.S.S. range more than 12 per cent. Jain Food Park Industries, Jalgaon introduced White Creole, which further subjected to selection pressure, for high T.S.S. character and developed V-12 variety with T.S.S. range from 15-18%. This variety is under contract production for processing but seed production is not possible under Indian plains.

Since, establishment of NRC for Onion and Garlic in 1998 at Rajgurunagar, a special programme for development of high T.S.S. white onion variety was launched through selfing and massing from available germplasm. In the year 2000 about 7199 bulbs were examined for T.S.S. range. Only 2.72% bulbs recorded T.S.S. more than 14 per cent. 109 bulbs offering T.S.S. range from 15 to 23% were selfed and populations were developed. After rejecting poor performing populations, 30 populations having 16 to 19% T.S.S. are advanced. In 4th generation of selection cycle we are able to achieve more than 75% bulbs having average TSS about 18% or even more in about 15 populations in short day onion. It would be possible to develop high T.S.S. open pollinated varieties within 2 to 3 years time suitable for *rabi* and late *kharif* seasons. Further, the programme for incorporation of high T.S.S. genes from long day and intermediate exotic cultivars to Indian genotypes is initiated in temperate region of Srinagar. Other options of mutation breeding are also being tried. Kataria (1990) reported three white mutants developed through chemical and physical mutagens viz., 22-5-1-1, 22-9-2-2 and 106-13-1-1 having TSS range from 25-30 per cent. This excellent material never reflected further in the form of either commercial variety or breeding material for varietal improvement.

Breeding for export quality onion

India is number one in export of onion followed by Netherlands. India's export is mostly to South East Asian and Gulf countries. Dark red and light red onions with globe shape are mostly preferred with various diameter sizes. The present practice of export is grading and packing from the total bulk arriving in various onion markets. Uniformity is shape size and colour is seldom attained, as there no systematic control over planting of required varieties. Further, there is lack in varieties, which can suit to exclusive markets. European markets require yellow or brown onion with big size. There are hardly any indigenous varieties, which can meet to these standards. NRCOG has initiated work in this direction and recommended Mercedes, Linda Vista, Cougre and Collina from exotic material for growing in late Kharif season. There is need for development of varieties in dark red and light red colour exclusively for export markets. Breeding work using long day and intermediate day exotic varieties with aim to transfer desirable characters in short day onion varieties is undertaken by this Directorate in collaboration with CITH Srinagar. Crosses were made and further selections for desirable characters were done which is further followed by mass selection.

Breeding for yellow onion

Indians do not prefer yellow onion but these find international market in European. Minimum requirements for export are: bigger sized (>60 mm diameter), less pungent and single-centered types. As is evident, most work has been done in European countries and USA whereas, in India, research on onion has not been of any great significance. "NuMex Starlite", a new yellow-onion variety developed by Corgan and Holland (1993), was resistant to bolting, *Pyrenochaeta terrestris* and the short-day type was obtained by 5 recurrent selections from Texas Grano 502 PRR. Among the 12 short-day onion cultivars assessed at Hermosillo, Mexico (Warid and Loaiza, 1996), all the yellow cultivars had high yields. Seville, 9003C, Bravo, Quest and Sweet Perfection gave [and were graded Jumbo (3-4 inches in diameter)] highest marketable yields of the 30 yellow cultivars tested over 2 years (Shock *et al* (2000) and had the most numerous bulbs. Texas 'Grano 1015 Y', a mildly pungent, sweet, short-day yellow onion variety, was developed by Pike *et al* (1988a) through original, single-bulb selection from Texas Early Grano 951 through 5 generations of selections. Similarly, "Texas Grano 1030 Y" was developed from F2 selections of Texas Early Grano 502 x Ben Shemen by Pike *et al* (1988b), which is a late maturing mildly pungent short-day onion variety. Very little work has been done in India for development of yellow onion varieties, particularly for export. Only two varieties were developed, viz., Phule Swarna from MPKV, Rahuri and Arka Pitambar from IIHR, Bangalore and were released at the state / institute level. Yield of these varieties was comparatively less than in commercial red onion varieties. Mohanty *et al* (2000) assessed 12 varieties of onion during *kharif* season and found lowest bulb diameter of 4.2 cm in Arka Pitambar, along with low yields.

Varietal Development with special reference to climate change

Climate change due to global warming and pollution has become major concern to the crop scientists and how to address this and prepare for is an important issue. Effect on total ecology and subsequently on certain important commodities is really not being studied. Onion and garlic are no bar to this shortcoming. No systematic studies are done in this regard. However, visible effect on distribution of rainfall has been noticed, which had exercised effect on increasing disease and pest in *Kharif* onion. *Kharif* onion is a very sensitive and crucial crop in meeting domestic supply from October to January. Failure of *Kharif* crop leads to hike in prices. Sudden rise in temperature in *rabi* season during December-January result in poor bulb initiation and bulb development of *rabi* onion and garlic. Dry weather with high temperature favours incidence of thrips and mites on these crop. Very high temperatures in March-April-May lead to reducing keeping quality of onion and garlic bulbs. Detailed studies under simulated conditions of weather parameters need to be initiated for understanding critical impact of climate change on different crops. Work on development of photo and thermo insensitive varieties is undertaken at Directorate of Onion and Garlic Research, Rajgurunagar to tackle the changing climatic situations. Some of the germplasm were found promising and can be grown in all the three seasons *viz.*, *Kharif*, late *Kharif* and Rabi seasons is being exploited for such situations.

Though onion is biannual in nature, extremely cross-pollinated crop, shows inbreeding depression, have less storage life of seed etc. But looking to the methods exploited in onion improvement in the world, there is lot of scope for population improvement in India also in following areas but one has to work with patience. There is need for identification of areas where off season seed can be produced or to standardize techniques of seed production during kharif season to reduce the time of breeding from biannual to annual particularly for late kharif and rabi season varieties. Some of the reports are available where efforts were made to produce seed during kharif season which was successful (Mahajan et al., 2002) and can be exploited for population improvement for rabi and late kharif onion varieties. There is need to develop 1. Varieties for different seasons, 2. Varieties for biotic and abiotic stress, 3. Varieties for processing, 4. Varieties for green foliage, 5. Varieties for export quality, 6. Varieties for mechanized farming for large as well as small farmers 7. Varieties for better keeping quality, 8. Varieties according to consumers demand, 9. Varieties for organic cultivation, 10. Varieties for set planting and 10. Varieties to face Climate Change.

Garlic breeding

Traditional garlic-breeding research has been limited to evaluation for yield and other morphological characters to identify the best genotypes (Figliuolo *et al*, 2001; Khar *et al*, 2005a, 2005b). Genetic studies have revealed positive interaction between plant-height, bulb-weight, bulb-diameter and mean clove-weight (Zhila, 1981). Significant positive correlation between clove and bulb mean-weight, negative correlation between clove mean-weight and clove-number has also been reported (Baghalian *et al*., 2005). Variation in yield is explained by leaf number and bulb mean-weight. Therefore, these important characteristics could help in garlic selection programme and yield improvement (Baghalian *et al*, 2006). Although garlic is propagated vegetatively, considerable variation has been found in morphological traits (Shashidhar and Dharmatti, 2005; Khar *et al,* 2006). Major characters found to contribute to genetic diversity are bulb weight, diameter, yield, number of cloves per bulb, maturity, plant height, number of green leaves and bulbing period. Diversity assessment on the basis of morphological (Panthee *et al*, 2006; Baghalian *et al*, 2005), physical-chemical, productive and molecular characteristics, allicin content (Baghalian *et al.*, 2006), productive and qualitative characteristics (Resende *et al*, 2003) and chemotaxonomic classification (Storsberg *et al*, 2003) have been studied. In diversity assessment, Baghalian *et al*, (2005) did not detect any significant relationship between genetic diversity and geographical origin. Therefore, probably, genetic factors have more influence than ecology. Allicin is a major chemical constituent of garlic and is use in harmaceuticals. Multiple factors, viz., genotype, environment, S fertilization and light spectrum (Huchette *et al*, 2005), relative water content, soil type and harvesting date (Yang *et al*, 2005) have been found to influence allicin content in garlic bulbs, whereas, Baghalian (2005) found no significant correlation between ecological condition and allicin content. Production of true seed in garlic (*Allium sativum* and *A. longicuspis*) has been known for several years. It was with the discovery of fertile clones by Etoh (1986) that efforts were started to induce flowering and seeds in garlic. With the advent of flowering garlic, Jenderek and Hannan (2004) were able to evaluate reproductive characteristics and true seed production in garlic germplasm and were successful at producing S1 bulbs in a few fertile clones. This represented valuable material for studies on garlic genetics (Jenderek 2004). Jenderek and Zewdie (2005) studied within and between family variability for important bulb and plant traits and observed that bulb weight, number of cloves, and clove weight were the main factors contributing to yield, and concluded that vegetative propagation of garlic over the centuries had produced highly heterozygous plants. Koul *et al* (1979) studied prospects for garlic improvement in the light of its genetic and breeding systems and Simon and Jenderek (2004) made a comprehensive review about flowering, seed production and genesis of garlic breeding. Cultivated garlic, being non-flowering, has limited variability. Breeders depend upon natural clonal mutations and selection of superior clones from the germplasm. Induced mutations and somaclonal variation are the best way to broaden germplasm.

Improvement of garlic

Being an asexually propagated crop, methods of improvement through cross- pollination are not viable in garlic. Most of the varieties developed are through introductions and clonal selection. Based on temperature and day-length response, garlic has been classified as having long-day and short day varieties. It has also been classified as having hard neck and soft neck varieties. Hard-neck varieties bolt and flower but these flowers are usually sterile, while soft-neck varieties do not flower at all. Hard neck varieties cannot be braided for storage whereas softneck varieties can be braided and stored. Hard neck (long- day varieties) is characterized by big bulbs, less number of cloves (10-15), ease of peeling and, generally, have low storage life. Typical examples are Agrifound Parvati and Chinese garlic. Because of big size, their productivity is higher and these fetch a good price in local and international markets. Soft-neck (short-day) varieties are characterized by small bulbs, more number of cloves (20-45), more aroma and are, generally, good storers e.g., Indian garlic varieties G41, G1,G50, G282, etc. On the basis of consumption, area and production statistics, garlic is an important commodity in the Indian market, yet, public or private research on this crop has been less than encouraging. The main reason for this may be its asexual nature which limits breeding methods and area under its cultivation. At the international front, there are a few reports of flowering and seed production, but even now garlic is considered a sexually sterile species. Breeding methods for development of garlic are limited to clonal selection and mutagenesis among conventional methods, and somaclonal variation among biotechnological approaches. In India, most varieties have been developed through clonal selection and one or two through introduction. National Horticultural Research and Development Foundation (NHRDF) has been at the forefront of garlic research (with maximum number of varieties developed under their research programmes), followed by agricultural universities, viz., Gujarat Agricultural University (GAU), Punjab Agricultural University (PAU), MPKV, Rahuri, etc. Most of the varieties developed in these institutes are shortday type and can be grown under tropical and sub tropical climates. Some temperate varieties have also been released at the national level and prominent among them is Agrifound Parvati. Other temperate varieties of significance are VLG-1 (VPKAS, Almora), SKUAG 1 (SKUAST, Srinagar), DARL 52 and Solan Local (YSPUHF, Solan). Besides these, varieties selected by farmers over the years are also available in the market, e.g., Jamnagar Local, Ooty Local, Jeur Local etc. At present, there are 25 varieties in garlic (Table 5).

Table 5. Varieties of garlic developed by various organizations in India

Sr. No.	Organisation	Varieties
1.	MPKV, Rahuri	Godawari (P), Sweta (W), Phule Baswant (P)
2.	IARI, New Delhi	Pusa Sel – 10
3.	HAU, Hisar	HG 1 (W), HG 2 (W)
4.	NHRDF, Nasik	G-1 (W), G-41 (W), G-50 (W), G-282 (W), Agrifound Parvati (P), G-323 (W), W-189 (W)
5.	VPKAS, Almora	VL-6 (W), VL-7 (W), VLG 1 (W), VGP-5 (W)
6.	ARU, Almora	ARU 52 (W)
7.	PAU, Ludhiana	Punjab Garlic –1, Garlic 56-4 (W)
8.	GAU, Gujarat	GG-1 (W), GG-2 (W), GG-10 (W)
9.	DOGR, Rajgurunagar	Bhima Omkar (W), Bhima Purple (P)
10.	TNAU, Coimbatore	Ooty 1 (W)
11.	DARL	DARL 52 (W)
12.	Bihar Agril. College, Sabour	RAUG-5 (W)

Molecular markers in onion and garlic

Allium is a large genus of approximately 600 species and classification of such a large genus has proved difficult and many ambiguities still remain. Havey (1991) suggested that there could be a role for genetic markers in systematic studies of *Allium*. Bark *et al* (1994) studied introgression of *A. fistulosum* genes into *A. cepa* background using restriction fragment length polymorphism (RFLP) analysis. Van Heusden *et al* (2000) presented a genetic map based on amplified fragment length polymorphism (AFLP) in an interspecific cross of *A. roylei* and *A. cepa* and reported one of the allinase genes (a key enzyme in sulphur metabolism) and a Sequence Characterised Amplified Region (SCAR) marker linked to the disease resistance gene for downy mildew on the map. Gokce *et al* (2002) sequenced the genomic region corresponding to the cDNA revealing the closest RFLP to Male sterility (Ms) gene in their efforts on molecular tagging of the Ms locus in onion. Mapping studies in onion have thus far been scarce. King *et al* (1998) presented a low-density genetic map of restriction fragment length polymorphism (RFLP) based on an interspecific cross showing, that, genomic organization of onion was complex and involved duplicated loci. Reasons for delay in molecular marker studies in onion are: biennial nature of onion, it's severe inbreeding depression and its huge genome size. While RAPDs have been used successfully for genetic studies in *Allium*, the size of the genome may cause many problems, such as rather poor reproducibility and high backgrounds. Simple Sequence Repeats (SSRs), also called microsatellite markers, are codominantly inherited and reveal high levels of polymorphism. Fischer and Bachmann (2000) identified a set of informative STMS (Sequence Tagged Microsatellite Sites) markers for which can be used for distinguishing accessions and for studying interspecific taxonomic analysis using close relatives of *A. cepa*. Molecular characterization has been carried out in 20 accessions belonging to 14 *Alliu*m species using 5 isozyme and 15 RAPD markers by Lakhanpaul et al., 1996, indicated the presence of narrow intra-specific and high inter-specific variations in *Allium* species. The RAPD markers were useful for assessing relatedness and genetic diversity in onion cultivars. Mahajan *et al.* (2009) studied 14 short day and 2 long day cultivars of onion at 24 microsatellite loci. Twenty-one primer pairs were polymorphic. Nashik Red and Poona Red cultivars showed 100% similarity and were indistinguishable. Cultivars N-53 and Bombay Red showed 95% similar fragments. It was followed by Arka Niketan and Poona Red (91.3% similar fragments) and Arka Niketan and Nashik Red (90.5% similar fragments pair), which were quite close. Alisa Craig showed maximum diversity with about 70% dissimilar fragments pairs compared to other cultivars and showed 25.7% similar fragment pairs with Brigham Yellow Globe. Some fragments were unique and were only present or absent in a cultivar at particular loci can be used as cultivar specific markers for rapid discrimination. Based on Jaccard's coefficient for SSRs, cultivars were grouped into 5 main groups. Exotic cultivars Alisa Craig and Brigham Yellow Globe were different compared to the Indian cultivars. Nashik Red and Poona Red were indistinguishable and similarly N-53 and Bombay Red were quite close. It will also be helpful in selecting the diverse parents (inbreds) for the development of suitable hybrids of onion, for the DNA fingerprinting of the cultivars and promising germplasm for their protection under Plant Cultivar Protection act.

Garlic has been cultivated for millennia, but the taxonomic origins of this domestication process have not been identified. Modern taxonomy subdivides the world's garlic germplasm into five distinct groups: Sativum, Ophioscordon, Longicuspis, Subtropical and Pekinense (Fritsch and Friesen, 2002). The Longicuspis group from central Asia is recognized as the most primitive, the one from which the other group were derived (MaaB and Klaas, 1995; Etoh and Simon, 2002; Fritsch and Friesen 2002). Central Asia was hypothesized to be the primary centre of garlic evolution and diversity (Fritsch and Friesen 2002), and recent studies on primitive garlic types in the Tien-Shan mountains strongly support this assumption (Etoh, 1986; Kamenetsky *et al*, 2003).

A wide range of morphological diversity has been observed in garlic including flowering ability, leaf traits, bulb traits, plant maturity, bulbing response to temperature and photoperiod, cold hardiness, bulbil traits and flower traits (Simon and Jenderek, 2003). MaaB and Klaas (1995) included subtropical and Pekinense clones in their study, and suggested that the subtropical clones were clearly separated from all other types, while the Pekinense subgroup was relatively similar to the stalking type. RAPD techniques have been mostly reported for characterization of garlic germplasm from different researchers all over the world. RAPDs have been used for characterization of Australian (Bradley *et al,* 1996), Taiwanese (Hsu *et al,* 2006), Brazilian (Buso *et al*, 2008), Chinese (Xu *et al*, 2005), Chilean (Paredes *et al*, 2008), Guatemalan (Rosales *et al*, 2007) and Indian garlic (Khar *et al*, 2008). In addition to this, AFLP (Amplified Fragment Length Polymorphism) technique has also been used to characterize garlic (Ipek *et al*, 2003; Lampasona *et al*, 2003; Volk *et al*, 2004; Ipek *et al*, 2005).

Ipek *et al* (2003) compared AFLPs, RAPD and isozymes for diversity assessment of garlic and detection of putative duplicates in germplasm collections and concluded that there was good correlation between the markers and demonstrated that genetic diversity among closely-related clones, which could not be differentiated with RAPD markers and isozymes, was detected by AFLPs. Therefore, AFLP is an additional tool for fingerprinting and detailed assessment of genetic relationships in garlic. Most of the reports have concluded that diversity assessment is not correlated with geographical location though a few studies reported correlation between geographical locations and the diversity (Lampasona *et al*,, 2003). Volk *et al* (2004) reported that 64% of the U.S. National Plant Germplasm System's garlic collection, held at the Western Regional Plant Introduction Station in Pullman, Washington, USA, and 41% of commercial garlic collections, were duplicates. Rapid characterization of garlic accession is important for avoiding duplicate genotypes. For this purpose, Ipek *et al* (2008) developed several locus-specific polymerase chain reaction (PCR) based DNA markers and tested them for characterization of garlic clones and concluded that locus specific markers could be used as another tool for rapid characterization of garlic germplasm collection. Markers have also been used to clarify the taxonomic status of other well-characterized locally grown garlics (Ipek *et al*, 2008; Figliuolo and Stefano, 2007). Geneic fidelity of micropropagated crops (Al Zahim *et al,* 1997, 1999), traits like pollen fertility (Etoh *et al,* 2001) and marker related to white rot (Nabulski *et al*, 2001) have also been reported. A wide range of morphological diversity has been observed in garlic including flowering ability, leaf traits, bulb traits, plant maturity, bulbing response to temperature and photoperiod, cold hardiness, bulbil traits and flower traits (Simon and Jenderek, 2004). With the reporting of flowering garlic, linkage maps have been developed (Ipek *et al,* 2005; Zewdie *et al*, 2005) which will help tag important genes in future.

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Genetic diversity and conservation in major spices

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India is one of the 12 centers of origin of cultivated plants, is figured with two hotspots - the Western Ghats and the Eastern Himalayas, in an identification of 18 biodiversity hotspots carried out in the eighties (Myers 1988). Recently Myers *et al.* (2000) updated the list to 25 hotspots in their revised classification and the two hotspots extended to India are the Western Ghats/ Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas). In India, species richness in often accompanied by enormous genetic diversity found within individual species. India is one of the Vavilovian centres of diversity and origin and is said to be the centre of domestication to cardamom. The family Zingiberaceae is considered to be a spice family because, out of the 109 spices listed out by the International Standards Organization, 15 listed from Zingiberaceae.

Black pepper (*Piper nigrum* L.)
Biodiversity and distribution of black pepper

Piper nigrum belongs to the family Piperaceae. The *Piper* species are mostly woody perennial climbers, herbs or shrubs and distributed pantropically. The International Plant Name Index (www.ipni.org) has recorded 6704 *Piper* species in their website. Maximum diversity of *Piper* species occurs in American tropics (700 spp.) followed by Southern Asia (300 spp.), where the economically important species *Piper nigrum* L. (black pepper) and *P. betle* L. (betel vine) originated (Jaramillo and Manos, 2001). Ridley (1924) documented 75 *Piper* species from the Peninsular Malaya region. De Candole (1910) enumerated 133 species of *Piper* occurring in Philippines. Later Quisumbing (1930) conducted systematic study of the Philippine Piperaceae and he documented only 87 species from Philippines.

The distribution of *Piper* species ranges form sea level to the high ranges of Andes to and the sub Himalayas. (Royle 1839). Trans – Gangetic region and the South Deccan are considered to be the two independent centres of origin of the genus *Piper* in India (Hooker, 1886). However, the studies conducted by Rahiman (1987) states that there are three major centers for *Piper* in India. The centers postulated by Rahiman are (1) the sub-Himalayan and north East Indian centre extends from Siwalik range near Pakistan to Mismi hills in the Arunachal Pradesh, through Kumaun, Nepal, Sikkim and Bhutan. The second one *viz*. the Western Ghat centre extend from Vada near Mumbai to Mahendragiri near Kanyakumari through Khandala ghats, Mahabaleswar, Goa, Khanpur, Bababudani hills, Anamalai hills and Cardamom hills. The third centre is the Eastern Ghat extend from the Chittoor area in Andhra Pradesh to the Puri area of Orrisa. *Piper* species are also distributed in Andaman and Nicobar Islands.

Domesticated diversity

Cultivar diversity (Tables 1 and 2) is one of the principal components of diversity in black pepper. The cultivars are evolved directly from the wild *P. nigrum*. Natural selection and conscious selection by man for various traits have created diversity in cultivars. Most of the vernacular names of black pepper varieties indicate a specific feature of the vine such as colour or appearance of the vine, leaf shape, spike features or the place from which the vine originated initially. More than 100 cultivars are known today. About 60-65 of them are prevalent in cultivation. Some of the local varieties are confined to only in small pockets and are considered as cultivars of less importance. Cultivar diversity is maximum in Kerala followed by Karnataka. The cultivar diversity occurring in Kerala and Karnataka are listed below.

Table 1. Black pepper diversity occurring in Kerala

Sl. No	Name of the cultivar	Remarks
A. Cultivar diversity occurring in Central and southern Kerala		
1.	Aimpiryan	High yielding, performance excellent in higher elevations, good in quality. But late maturing, vigorous vines.
2.	Arakkulammunda	Moderate and regular bearer, medium in quality, well adapted
3.	Balankotta	Cultivar with large droopy leaves, moderate and irregular bearing.
4.	Chengannurkodi	Moderate yielder from South Kerala, medium in quality.
5.	Cheppakulamundi	Moderate yielder from Central Kerala, medium in quality
6.	Jeerakamundi	Cultivar with small leaves and short spikes, alternate bearing nature, small berries.
7.	Karimunda	Most popular cultivar suitable for most of the black pepper growing areas, high yielder and medium in quality, shade tolerant.
8.	Kottanadan	A high yielding cultivar from South Kerala, drought tolerant type.
9.	Kuthiravally	A cultivar with long spikes, high yield and good quality.
10.	Kuttianikodi	A moderate yielder from Central Kerala with relatively long spikes and good spiking intensity.
11.	Malamundi	A moderate yielder, medium in quality
12.	Narayakodi	Popular in South Kerala, moderate yielder with medium quality. Not easily affected by foot rot.
13.	Neelamundi	A good yielder from central Kerala medium in quality, tolerant to *Phytophthora* infection
14.	Nedumchola	A cultivar with small leaves and short spikes, moderate yielder.
15.	Neyyattinkaramundi	A cultivar from Central Kerala, medium in quality and yield.
16.	Perumkodi	A cultivar from Central Kerala, moderate in yield and quality.
17.	Poonjaranmunda	A cultivar originally from Central Kerala, sporadically found in gardens of North Kerala. Moderately good in yield and quality.
18.	Thommankodi	A cultivar from central Kerala, moderately good in yield and quality.
19.	Thulamundi	A Central Kerala cultivar, medium in yield and quality.
20.	Vattamundi	A moderate yielder from Central Kerala.
21.	Vellanamban	Relatively moderate yielder and medium in quality characterized by the light green colour of the young shoot tip.
B. Cultivar diversity occurring in Northern Kerala		
22.	Cheriyakaniakadan	Popular in North Kerala, moderate and early bearing variety.
23.	Kalluvally	A promising North Kerala cultivar, good yielder, medium in quality with high dry recovery, drought tolerant.
24.	Kottan	A cultivar found in North Kerala, moderate in yield and medium in quality
25.	Manjamundi	A moderate yielder from North Kerala, medium in quality.
26.	Perambramunda	A cultivar from North Kerala, moderate yielder with medium quality.
27.	Vadakkan	A cultivar from North Kerala, medium in quality and yield with relatively large berries.
28.	Valliyakaniyakadan	A cultivar with larger leaves, medium in yield and quality.

Table 2. Black pepper diversity occurring in Karnataka

Sl. No	Name of the cultivar	Remarks
1	Bilimallegesara	Moderate yielder with light green spikes
2	Kurimalai	A cultivar from Karnataka, moderate yielder with medium quality.
3	Karimaratta	A moderate yielder with uniform bearing
4	Karimalligesara	Moderate yielder with dark green spikes
5	Malligesara	A common cultivar from Karnataka, relatively good in yield.
6	Uddagara	A popular cultivar of Karnataka, good in yield and medium in quality.

Table 3. Released varieties of black pepper in India

	Variety	**Pedigree/Parentage**	**Important traits**
Pepper Research Station (KAU), Panniyur			
1	Panniyur 1	Inter-cultivar hybrid of Uthirankotta x Cheriyakaniyakadan	Vigorous growing vine. Medium maturity group. Long spikes, close setting of berries, bold berries, oleoresin 11.8%, piperine 5.3%, essential oil 3.5%, dry recovery 35.3% with yield of 1242 dry pepper/ha
2	Panniyur 2	Clonal selection from open pollinated progeny of Balankotta	Shade tolerant, suitable for intercropping, medium maturity group, medium quality oleoresin 10.9%, high piperine (6.6%), essential oil 3.4%, dry recovery 35.7% with yield of 2570 kg dry pepper/ha
3	Panniyur 3	Inter-cultivar hybrid of Uthirankotta x Cheriyankaniyakadan	Suitable for all pepper growing regions, performs well under open situation. Late maturity group. Long spikes and bold berries, piperine 5.2%, oleoresin 12.7%, essential oil 3.1%, dry recovery 27.8% with yield of 1953 kg dry pepper/ha
4	Panniyur 4	Clonal selection from Kuthiravally type II	Stable yield er, performs well under adverse condition also, tolerant to shade, late maturity, 4.4% piperine, 9.2% oleoresin, 2.1% essential oil and 34.7% dry recovery with yield of 1277 kg dry pepper/ha
5	Panniyur 5	Clonal selection from open pollinated progeny of Perumkodi	Suitable for both mono and mixed cropping in coconut/arecanut gardens, shade tolerant, medium maturity, tolerant to nursery disease. Long spikes, piperine 5.3%, oleoresin 12.33%, essential oil 3.8% and dry recovery 35.7% with yield of 1110kg dry pepper/ha
6	Panniyur 6	Clonal selection from Karimunda type III	A vigorous vine. Tolerant to drought and adverse climatic conditions, stable and regular bearer, medium maturity group. Suitable for open condition as well as partial shade, spike 6-8cm, more number of spikes/unit area, close setting and attractive bold berries, piperine 4.9%, oleoresin 8.27% and essential oil 1.33% and 33.0% dry recovery with yield of 2117 kg dry pepper/ha
7	Panniyur 7	Open pollinated progeny of Kalluvally	Vigorous vine and a regular bearer, long spike, a hardy type vine, tolerates adverse climatic condition, suitable for open and shaded conditions, very long spike (16-24cm) high piperine content (5.6%), oleoresin 10.6%, essential oil 1.5%, and 34.0% dry recovery with yield of 1410 kg dry pepper/ha
8	Panniyur 8	Inter-cultivar hybrid progeny of Panniyur 6 x Panniyur 5	Plants vigorous, regular bearer, performs well under open and shaded conditions, tolerant to drought and *Phyothpthora* foot rot. Suitable for all pepper growing regions of Kerala.
NRC for Oil Palm, Regional Station, Palode			
9	PLD –2	Clonal selection from Kottanadan	Late maturity high quality cultivar, contains piperine 3.0%, oleoresin 15.45%, essential oil 4.8%. Suitable for plains and higher elevations with yield of 2475 kg dry pepper/ha.

		IISR, Calicut	
10	Sreekara	Clonal selection from Karimunda (KS 14)	High yield and quality, Adaptable to various climatic conditions in all the pepper growing tracts, yield 2677 kg dry pepper/ha
11	Subhakara	Clonal selection from Karimunda	High yield and quality, wider adaptability, yield 2352 kg dry pepper/ha
12	Panchami	Clonal selection from Aimpiriyan	A high yielding variety with excellent fruit set. Spike twisted in appearance due to high fruit set. Oleoresin content is high, yield
13	Pournami	Clonal selection from germplasm (ottaplackal 1)	Tolerant to root knot nematode. A moderately high yielding vine with high oleoresin content , yield 2333 kg dry pepper/ha
14	IISR Thevam	Clonal selection from Thevamundi	Tolerant to foot rot diseases. Suited to high altitude areas, mean yield 5.17 Kg per line (Fresh)
15	IISR Malabar Excel	Cholamundi X Panniyur 1	Suitable for higher elevation and plains, mean yield 2.78 kg per line (Fresh)
16	IISR Girimunda	Narayakodii X Neelamundi	Medium maturing type, mean yield 6.14 kg per line(fresh)
17	IISR Shakthi	Open pollinated progeny of Perambramundi	Moderately resistant to Phytophthora

(Singh *et al*., 2009)

Economically important Piper spp.

Includes important cultivated species like *P. nigrum*, the black pepper, *P. betle*, the betel vine, *P. longum, P. chaba, P. peepuloides, P. hapnium, P. cubeba*, the long pepper, *P. cubeba, P. methysticum* etc. The dried fruits, the powdered forms or as a whole and oils and oleoresin extracted from the berries are used all over the world. *Piper betle* L. is widely cultivated in India for its leaves for the pan industry.. The essential oil from leaves is used in respiratory catarrh and also as an antiseptic (Ravidnran, 2000). The plant is considered by the tribal as useful in treating madness, strangulation of the intestine, venereal sore etc. (Jain and Tarafder 1970). Long pepper (*Piper longum* L.) is used in Ayruvedic and Unani systems of medicine. Long pepper is an important constitutent in the Ayurvedic preparation such as *Trikadu* (dry ginger-long pepper-black pepper) and panchakolam. Both fruits and dried roots are used for medical preparations. The long pepper of commerce appears to be derived from five *Piper* species viz. *P. peepuloides*, *P. hapnium*, globoid spikes of *P. mulleusa* besides P.*longum and P.chaba.* (Sasikumar, 2003). The Indonesian or Java long pepper (*P. chaba*) is also known as Gaja thippali or Bengla thippali is another variety of long pepper. The species is cultivated in Assam and West Bengal and also in Indonesia/Malysia. True Indian long pepper is derived from *P. longum*, from wild grown plants in Assam, West Bengal, Nepal, North Eastern region, Bihar, Uttar Pradesh, Kerala, Tamil Nadu, Andhra Pradesh etc. It is also cultivated in Kerala, Andhra Pradesh and Maharashtra in a small scale. “Viswam” is an improved variety of *Piper longum* from Kerala Agricultural University, Trissur, Kerala.

Cubeb or tailed pepper (*Piper cubeba* L) cultivated in Indonesia and Malaysia is having high therapeutic value. Fruits and oil extract of *P. cubeba* are used in treatment of asthma. Kawa pepper- *P. methysticum* G. Frost- a native of South Pacific Islands is used to make a non-alcoholic but narcotic drink, Kawa – a ceremonial drink among the Polynesians since ancient period (Ravindran 2000). The roots of *P. sylvaticum* Roxb are widely used in indigenous medicine as an effective antidote for snake poison (Banerji and Dhara 1974). In Peninsular Malaysia, the decoction made from the leaves of *Piper sarmentosum* Roxb. is used for curing pains in bones and applied to the foreheads of children suffering from headaches. *Piper umbellatum* (stomach ache, cough) *P. poryphyrophyllum* (leprosy, stomach ache and skin diseases) are the other two *Piper* species used in Peninsular Malaysia (Tawan *et al*. 2002). *Piper kadsura* (Choisy) Ohwi, a native of Taiwan is used for the treatment of asthma and arthritis in Taiwan (Linn and Lu 1996). Recent studies indicated that this plant has got inhibitory properties on Hepatitis B (Ray-Ling *et al*. 2001)

Besides these economically important species there are some *Piper* species having ornamental value having attractive foliage. *P. auritum, P. borneense, P. decurrens, P. magnificum, P. metallicum, P.*

ornatum, P. porphyrophyllum, P. rubronodosum, P. rubrovenosum etc are valued for ornamental purpose (Greiffith 1992).

Conservation

Even though the early movement of settlers across the length and breadth of Kerala helped the spread of landraces (cultivars) to new areas, the advent of improved- yield black pepper varieties is becoming a threat to many of the old cultivars. The depletion of forest area, rampant destruction of the forest trees and undergrowth, and changes in the agro-ecological conditions all have led to sharp decline in the populations of wild pepper and their related taxa. The species of *Piper* that are most affected by deforestation are *P. barberi, P. hapnium, P. silentvalleyensis, P. wightii and P. schmidtii*. Many of the taxa are now confined to only a few specific locations and may soon be extinct, if not collected and conserved. Concerted efforts were made by Indian Institute of Spices Research, Calicut, All India Coordinated Research Project on Spices, National Bureau of Plant Genetic Resources, Regional station, Trissur and Kerala Agricultural University to collect and conserve the black pepper and its wild relatives.

In situ conservation

In - situ conservation of biodiversity is safer and more desirable than *ex-situ* conservation in the case of wild relatives. Here the species conserved is subjected to co-evolve with the environmental changes. It is important that sanctuaries of wild relatives of crop species and other economically important species are to be established in the Western Ghat and north eastern region, which are considered to be the centers of origin of *Piper* species in India. In India the first gene sanctuary was established in Garo hills in Meghalaya for *Citrus* (Singh 1981). Velayudhan *et al* (1999) suggested the establishment of gene sanctuary for *Piper* species at Silent Valley since the diversity is more here. Based on the surveys conducted and the distribution studies conducted by Indian Institute of Spices Research, the Western Ghat region spreading from Waynad to Palaghat District and the Kollam, Tirunelvelli and Thiruvananthapuram district are the hotspots for *Piper* in south India. So it will be appropriate to establish *Piper* gene sanctuaries in these places. Wild species like *P. schmidtii* and *P. wightii* are distributed only in Nilgiris, Kodaikanal and Munnar (above 1500 m MSL). For conserving these high elevation species a gene sanctuary have to be established in Nilgiri forests under protected conditions.

Ex situ conservation

Field gene bank

Systematic surveys of all pepper growing areas, forests of the Western Ghats and part of the North Eastern regions were conducted to collect the available variability of cultivated forms as well as wild relatives and these accessions are being maintained at the black pepper germplasm conservatory at IISR, Kozhikode as field genebank as well as in the nursery. Presently, IISR is in a unique position of having the largest germplasm collection of black pepper in the world consisting of 2257 accessions (Table 5). Besides these accessions, over 1200 hybrids and 120 OP- lines are also maintained. Besides the germplasm collections of IISR, Kozhikode some accessions of black pepper germplasm are also maintained under the All India Coordinated Research Project on Spices at various places (Table 4).

Table 4. Black pepper germplasm maintained at NARS

S. No	Name of the center	Germplasm holding
1.	Indian Institute of Spices Research, Kozhikode	2257
2	Pepper Research Station, Panniyur	299
3	Horticulture Research Station, Sirsi	127
4	Horticulture Research Station, Chintapalle	58

5	Konkan Krishi Vidyapeeth, Dapoli	91
6	Horticulture Research Station, Yercaud	137
7	Uttar Banga Krishi Viswa Vidyalaya, Pundibari	25

(AICRPS, Annual Report 2009-10)

In vitro conservation

The germplasm conserved *in-situ and ex-situ* by means of field genebank are susceptible to many threat such as natural calamities, disease epidemics etc. For safe guarding the germplasm as an alternative source *in- vitro* conservation of important *Piper* species are attempted at IISR Calicut. The slow growth technologies for in-vitro conservation have been standardized and at present the *in-vitro* genebank is holding 35 accessions including the exotic collections. Besides IISR, Calicut, NBPGR, New Delhi is also conserving *Piper* species in there national conservatory (Ann. Report, 2003).

To summarize, the current status of species biodiversity assessment and conservation indicate that the vast areas of the North East is yet to be fully explored to get an understanding of the variability available and the emergency to collect and conserve them. The National Bureau of Plant Genetic Resources (NBPGR) station established at this region will have to expedite this activity and document the variability available, concurrently conserving the resources collected or transferring them to the respective commodity research institute for further evaluation and use in crop improvement. These explorations also will bring to light these species still underexploited that find way in local cuisine or medicine. Besides the above, introduction of exotic germplasm with desirable features may have to be envisaged for improvement of this spice and to meet global demand.

Ginger

Ginger (*Zingiber officinale* Roscoe) is a monocot belonging to the *Zingiberaceae*, a very large family which consists of 47 genera and 1400 species. It is a very important spice and medicinal plant known since antiquity. Many famous travelers and explorers from Marco Polo to Vasco Da Gama mention ginger. The origin of ginger is unertain but evidences indicate that it must have originated in South Asia to South East Asia. It was cultivation in China in antiquity and in India since *Vedic* times.William Shakespeare (1564-1616) mentions ginger in nine of this plays. The global trade of this crop is around US$ 247 million from top 20 countries while the value of global production is over US $ 913 million (FAOSTAT 2010). Nigeria has the largest area under ginger accounting for nearly a half the total world area while India ranks first in production contributing to 30% of global production. Australia leads the world in production of ginger confectionary products. While ginger is a valued culinary spice, its traditional use in medicine is ancient and it has been reported to possess a range of properties from an aphrodisiac to antipyretic. Ginger does not set seed and sexual recombination has never been reported, all the variability reported is clonal in nature.

Variability in cultivated ginger is encountered in China and India. Most of the land races are known after their place of domestication and hence all of them may not be distinct genetically. Geographical spread accompanied by genetic differentiation into locally adapted population augmented by mutation is the main factor responsible for diversity in this clonally propagated crop.

Genetic resources and variability

A large number of reports are available on variability in ginger. Since ginger cannot be propagated by sexual means, the variability that has been available in the existing clonal materials has been exploited. A wide array of diversity occurs in wild Western Ghats, India (Muralidharan and Velayudhan 1983; Sasikumar et al. 1995) however, maximum variation within cultivated ginger occurs in North East India. This is suggested to be due to geographical spread from its centre of origin in Southeast Asia accompanied by genetic differentiation into locally adapted populations caused by mutations

(Ravindran et al. 1994). China has the richest variability in ginger. The South East Asian gingers are classied into two groups, namely, sparse seedling type and dense seedling type based on growth (Xizhen et al. 2005). Like any other countries, the ginger in China also named after the place where it is cultivated or based on colour of rhizome.

Table 5. World ginger cultivars

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

(Parthasarathy *et al.,* 2011)

The associations of high heritability with high genetic advance for yield per plant (fresh), plant height, number of leaves/plant, number of tillers/plant, number of primary fingers, number of secondary fingers and internodal length of mother rhizome suggest that these characters are under the control of additive genes which can be improved through selection (Singh and Mittal 2003). Many reports are available on genetic variability and correlation in ginger. Singh et al. (1999) grouped 18 genotypes into 3 clusters. The major factors for divergence were rhizome yield per plant, oleoresin and fiber contents.

Table 6. Released varieties of ginger from India

	Variety	Pedigree/Parentage	Important traits
High Altitude Research Station, OUAT, Pottangi			
1	Suprabha	Clonal selection from Kunduli local	Plumpy rhizome, less fibre, wide adaptability, suitable for both early and late sowing, duration 229 days. 8.9% oleoresin, 4.4% crude fibre, 1.9% essential oil and 20.5% dry recovery.
2	Suruchi	Clonal selection from Kunduli local	Profuse tillering, bold rhizome, suitable for rainfed/irrigated conditions, duration 218 days. 23.5% dry recovery
3	Surabhi	Induced mutant of Rudrapur local	Plumpy rhizome, dark skinned yellow fleshed, suitable for both irrigated/rainfed, duration 225 days. 10.2% Oleoresin, 2.1% essential oil, 4.0% crude fibre, 23.6% dry recovery.
Department of Vegetable Crops, YSPUH &F, Solan			
4	Himgiri	Clonal selection from Himachal collection	Best for green ginger, less susceptible to rhizome rot disease, suitable for rainfed condition. 4.29% oleoresin, 1.6% essential oil, 6.05% crude fibre, 20.2% dryrecovery, 230 days duration.
IISR, Calicut			
5	IISR Varada	Clonal selection from Sarjiguda collection	High yield and good quality, 20.7 % dry recovery

6	IISR Rejatha	Clonal selection from Pampadumpara	High yield and plumy rhizomes, 19 % dry recovery, 2.36% essential oil, 6.34% oleoresin and 4.0% fibre content
7	IISR Mahima	Clonal selection from Pottangi selection	High yield and plumy rhizomes, 23 % dry recovery, 1.72% essential oil, 4.48% oleoresin and 3.26% fibre content
Kerala Agricultural University, Thrissur, Kerala			
8	Athira	Selection from Somaclones	High yielding, bold rhizomes, tolerant to soft rot and bacterial wilt, bold rhizomes
9	Karthika	Selection from Somaclones	High yielding, high pungent, tolerant to soft rot and bacterial wilt, bold rhizomes

(Singh *et al.,* 2009)

Resistance breeding in ginger is restricted to screening the germplasm for various pathogens and insect pests affecting the crop (Table **7**). The major quality components for which cultivars are being selected are good dry recovery percentage, low fiber, high oil, and oleoresins. In almost all the ginger growing countries cultivars are being selected for quality. The pungency of fresh ginger is due to a series of homologous phenolic ketones of which [6]-gingerol is the major one. The gingerols are thermally unstable and can be converted to their corresponding shogaols, which are present in dried ginger. Australian ginger oil has a reputation for possessing a particular "lemony" aroma, due to its high content of the isomers neral and geranial, often collectively referred to as citral. In South Africa, John and Ferreira (1997) found selection G13 (Brazilian) for the early harvest ginger (confectionery), the selections G10 (West Indies) and G9 (Taiwan) for the drying and extraction industries, respectively.

Table 7. Source of resistance to pests and diseases in ginger.

Name of disease (pathogen)	Cultivars	Remarks	Reference
Soft rot (*Pythium aphanidermatum*)	Nadia, Narasapattanam	Moderately resistant	Balagopal et al. 1974
	Maran	Resistant	Indrasenan and Paily 1974
	Maran	Least susceptible	Nybe and Nair, 1979
Phyllosticta zingiberi	Narasapatam, Nadan, Tetraploid, Thingpani, Tura,	Moderately resistant (5% infection)	Setty et al. 1995
	RGS-5, SG-554, V1S18	Field resistant	Singh et al. 2000
	Taiwan and Tafingiva	Least susceptible	Nybe and Nair 1979
Dichocrocis punctiferalis	Rio-de-Janeiro	Low incidence (21.3%)	Nybe and Nair 1979
Shoot fly (*Formosina flavipes*)	Suruchi	Low incidence (13.1%)	Chandramani and Chezhiyan 2002
Nematode (*Meloidogyne incognita*)	UP	Low multiplication of nematode	Routaray and Mohapatra1988
	IISR Mahima	Resistant	Sasikumar et al. 2003
	UP	Tolerant	Nehra and Trivedi 2005

Yield and quality traits (such as essential oil, fibre and oleoresin contents) along with volatile and non-volatile constituents are important determinants of the commodity's end product (Jaleel and Sasikumar 2011). Among oil composition of fresh rhizomes of 17 Australian ginger clones, the cultivar "Jamaican", yielded oil with a substantially different composition, lower citral content and higher levels of sesquiterpene hydrocarbons and significantly higher concentrations of gingerols, with a unique aroma and flavor characteristics (Wohlmuth et al. 2006). There were no significant differences in gingerol concentrations between the tetraploid clones and their parent diploid cultivars. Quality assessment revealed the suitability of 'Tura', 'Suravi', Suprabha, Uttar Pradesh and Gorubathan for the production of dry ginger; Suravi, Suprabha, Taffingiva and Jughijan for the extraction of oleoresins; and Suravi, Suprabha, Mazulay, Jughijan and Tura for essential oil extraction (Datta et al. 2003). Essential oil and oleoresins showed a negative correlation with dry matter (Goyal and Korla 2001). Significant variation among the cultivars was observed for oil, oleoresin, crude fiber and dry matter contents irrespective of growing conditions. The results indicated that SG 61, SG 62, BDJR 1054 and SG 687 are suitable for ginger oil and oleoresin extraction, whereas SG 692 was the most suitable for dry ginger production and processing. SG 646 was identified as a substitute for Himgiri for fresh ginger production under the mid-hill conditions of Himachal Pradesh, India (Tiwari 2003). A list of some of the cultivars and their quality parameters are presented in Table 8.

Table 8. Quality parameters of some ginger cultivars

Cultivars	Dry recovery (%)	Crude fiber (%)	Oil (%)	Oleoresin (%)
G10	27.5	-	-	-
G9	-	6.8	0.5	3.1
Himachal	21.2	4.5	1.65	7.5
IISR Mahima	23.0	3.2	1.72	4.5
IISR Rejatha	19.0	4.0	2.36	6.3
IISR Varada	20.7	4.5	1.75	6.7
Maran	20.0	4.4	1.95	6.8
Suprabha	20.5	4.4	1.9	8.9
Suravi	23.0	4.0	2.1	10.2
Suravi	23.4	-	2.1	10.3
Suruchi	23.5	3.8	2.0	10.0

Conservation

It is important to conserve the existing diversity. In a report from Nigeria, it was found that genetic erosions were 12.5 and 25.0% in ginger in 1996/97 and 1997/98 seasons, respectively. The high genetic erosion obtained implies that the genetic resources could be in danger and the management of germplasm should be improved in order to sustain and conserve them for future food security (Eke Okoro 1999). Genetic resources of *Zingiber* spp., particularly from clones available on farms, can be useful source to capture and utilize diversity for conservation as well as further improvement in ginger (Jatoi et al. 2008). An *Ex-situ* genebank of ginger at the Indian Institute of Spices Research, Kozhikode, India contain 659 accessions: 508 cultivars, 92 accessions of related taxa, and 59 exotic collections. Ginger germplasm maintained under various centers are listed in Table 9.

Table 9. Ginger germplasm collections in NARS centres

Center	Indigenous	Exotic	Total
Calicut	651	8	659
Kumarganj	63	-	63
Pottangi	174	3	177
Pundibari	19	6	25
Dholi	49	-	49
Raigarh	44	-	44
Solan	176	-	176
Total	1176	17	1193

(AICRPS, Annual Report, 2009-10)

Turmeric

There are about 100 species in the genus *Curcuma*, 41 are known to occur in India of which at least 10 are endemic to the Indian subcontinent. The ecology of the species varies so much that their habitat ranges from sea level (sandy coastal habitat) to high altitude such as above 2000 m in the Western

Ghats and Himalayas in India. While species such as *C. longa, C. zedoaria, C. amada* and *C. aromatica* are found predominantly in plains, *C. angustifolia*, *C. neilgherrensis, C. kudagensis, C. thalakaveriensis*, *C. pseudomontana* and *C. coriacea* etc. are confined to hills at 1000–2500m altitude (Velayudhan *et al*. 1999). Species diversity is at its maximum in south and northeast India and the Andaman and Nicobar Islands.

Taxonomic revision of the genus *Curcuma* is in progress. Since some of the existing species are now being recognized as synonyms such as *C. zedoaria* syn. *C. xanthorrihza* and *C. amada* closely resembles *C. mangga* for quality attributes it is likely that the number of species occurring in India may be reduced to just 30. Similarly, it has now been established that the Chinese species *C. albicoma* and *C. chuanyujin* are synonyms of *C. sichuanensis* and *C. kwangsiensis*, respectively. The Chinese species *C. wenyujin* is now recognized as a synonym of *C. aromatica*, *C. phaeocaulis* was misidentified in the past as C. *zedoaria, C. caesia* and *C. aeruginosa* in China (Liu and Wu, 1999). *C. kwangsiensis var. puberula* and var. *affinis* are not accepted and the identity of the Taiwan species *C. viridiflora* remains suspicious (Liu and Wu, 1999). However, new species, such as *C. rhabdota* are also reported from South-East Asia (Sirirugsa and Newman, 2000), *C. prakasha* spp. *nov*. from India (Tripathi, 2001), and *C. bicolor, C. glans* and *C. rhomba* from Thailand (Mood and Larsen, 2001).

Cultivar diversity

Many local cultivars of turmeric are known mostly by the names of the locality. Moderate genetic variability exists in crop and the cultivars vary in yield, duration and quality. About 50 cultivars of turmeric were identified. The region specific varieties are given in Table 10.

Table 10. Popular traditional cultivars of turmeric grown in different states of India

State	Cultivar
Andhra Pradesh	Duggirala, Mydukkur, Armoor local, Cuddapah, Kodur, Tekurpet, Kasturi, Chayapasupu, Armoor, Amdapuram
Karnataka	Kasturi, Mundaga, Balaga, Cuddapah, Rajapuri, Amalapuram, Shillong
Kerala	Alleppy, Moovattupuzha, Wyanad local, Tekurpetta, Armoor, Duggirala
Madhya Pradesh	Raigarh, Jangir, Bilaspur
Maharashtra	Krishna, Rajapuri, Sugandham
Orissa	Dindigam
Tamil Nadu	Erode, Salem
Meghalaya	Lakadong

Curcuma collections and species differ in floral characters, aerial morphology, rhizome morphology and chemical constituents (Velayudhan *et al.*, 1999). More than 70 turmeric types are known under cultivation in India belonging to *C. longa* and few cultivars that belong to *C. aromatica.* Existence of wide variability among the existing cultivars in respect of growth parameters, yield attributes, resistance to biotic and abiotic stresses and quality characters was reported by various workers.

The cultivars are grouped into short duration 'kasturi' types, medium duration' kesari' types and long duration types (Rao and Rao, 1974). Cultivars Armor, Tekurpet, and Mydukur are long duration crops; Kothapeta is medium duration crop while Kasturi is short duration crop. There is reasonable variation with regard to reaction to pests and diseases. Cultivars Mannuthy local, Kuchipudi are tolerant to shoot borer. Cultivars Mannuthy local, Tekurpeta, Kodur are tolerant to leaf spot while Mannuthy local, Glpuram-2, Kasturi Tanuku and Armoor are tolerant to leaf blotch. Suguna and Sudarshana were reported to be field tolerant to rhizome rot. Dry recovery, curcumin and oleoresin contents determine the quality of turmeric and high variability was observed in turmeric germplasm with respect to these characters (Khader *et al.* 1994). Turmeric is affected by foliar as well as rhizome diseases. Among the foliar diseases, leaf spot caused by C*olletotrichum capsici* and leaf blotch caused by *Taphrina maculans* are serious. Rhizome rot caused by *Pythium graminicolum* is the most serious malady of the crop. Identifying disease resistant varieties is an important breeding objective. The various collections of turmeric germplasm also exhibited high variability for resistance to various pests and diseases.

Table 11. Popular local cultivars of turmeric in India

No.	Popular cultivar	Yield ($t\ ha^{-1}$)	Reaction to pest & diseases
Andhra Pradesh - Kasthuri types			
1.	Kasturi Kothapeta	15-20	Susceptible to leaf spot Susceptible to leaf
2.	Kasthuri Tanuku	12-15	spot Susceptible to leaf spot
3.	Kasthuri Amalapuram	10-12	-
4.	Chaya Pasupu	--	
Andhra Pradesh -Kesari types (*C. longa*)			
1.	Kesari Duvvur	--	Susceptible to leaf blotch
2.	Amruthapani Kothapeta	25	"
Andhra Pradesh - long duration types			
1.	Duggirala	32	Susceptible to leaf spot
2	Tekurpeta	-	Tolerant to leaf spot
3	Mydukur	32	Susceptible to rot and leaf spot
4	Armoor	25	Susceptible to leaf spot, rot
5	Sugandam	20-25	Susceptible to leaf blotch
6	Vontimitta	20	-
7	Nandyal	-	-
8	Ayanigadda	15-18	-
Tamil Nadu			
1	Erode	30-32	-
2	Salem	--	-
Kerala			
1	Alleppey	25	-
2	Mannuthy Local	24	-
Assam			
1	Shillong	40	Tolerant to leaf blotch and rot Tolerant to leaf
2	Tall Karbi	30-40	spot and rot
Maharastra and Gujarat			
1	Rajapuri	20	Resistant to leaf spot and susceptible to
2	Eavaigon	45	blotch and rot

Ratnambal (1986) studied variability in quality parameters in over 100 collections of turmeric collected from India, belonging to both longa and aromatica types, a few exotic and wild collections and reported wide variability in curcumin, oleoresin, essential oil contents and dry recovery (Table 12).

Table 12. Variability for quality characters

Characters	Range	Promising cultivars/accessions
Curcuma domestica Val. (*C. longa* L)		
Dry recovery (%)	13.5 – 32.4	Ernad , Cls No. 5A Amrithapani, Kothapetta

		Amalapuram Sel. III
Oleoresin (%)	10.0 – 19.0	Chamakuchi
		Kayyam, Gudalur
		Palani
		Amalapuram Sel. III
		Rorathong, E. Sikkim
Oil (%)	4.0 – 9.5	Ernad,
		Kakkayam local
		Kahikuchi
Curcumin (%)	2.8 -10.9	Kaziranga, Jorhat
		CIIs 328 Sugandam
		Kayyam, Gudalur
		Edapalayam
		Erathukunnam
		Palapally, Trichur
C. aromatica Salisb		
Dry recovery (%)	14.0 – 28.0	Burahazer, Dibrugarh
		Hahim
		Konni
Oleoresin (%)	9.6 – 19.2	Konni
Oil (%)	4.0 – 9.0	Nadavayal
		Kasturi
		Armoor
Curcumin (%)	2.3 - 8.0	Dibrugarh

High heritability with appreciable genetic advance was reported for rhizome yield, crop duration, number of leaves, number of primary fingers, yield of secondary fingers and height of pseudostem. Singh *et al.* (2003) suggested superior genotypes may be obtained through selection based on the number and weight of mother, primary and secondary rhizomes.

The yield per plant was highly associated with length of primary fingers, mother rhizome diameter, length and girth of secondary fingers. The correlation coefficients of these yield components were positive and significant (Rao 2000). Number of leaves, number of primary fingers and crop duration had shown positive association with rhizome yield at both genotypic and phenotypic levels (Reddy 1987; Panja *et al.* 2002). The quality characters (curcumin, essential oils and oleoresins) had shown negative correlation. In crop improvement of turmeric, plant height and number of leaves determines the yield potential of the genotype (Narayanpur and Hanamashetti, 2003). It is therefore concluded that plant height is the single most important morphological character on which selection for yield could be made.

Genetic divergence studies (D^2 analysis) with 54 genotypes showed wide diversity among genotypes and were grouped in as many as six clusters (Rao, 2000). PCT-13 and Lakadong formed solitary groups and were genetically most distant. The land races of North East region were almost clustered in low to moderate yield groups, while genotypes from the southern region was scattered among different complexes ranging from moderate to high yielders (Chandra *et al.* 1997, 1999). PCT-14, 13 and 10 with shorter duration, medium yield with good curcumin content were identified as potential parents for future breeding programmes.

Table 13. Released varieties of turmeric from India

	Variety	Pedigree/Parentage	Important traits
TNAU, Coimbatore			
1	CO.1	Vegetative mutant by x-ray irradiation of Erode local	Bold and bright orange yellow rhizomes, curcumin 3.2%, oleoresin 6.7%, essential oil 3.7%, dry recovery 19.5%, suitable for drought prone, hilly areas saline and alkaline areas. Crop duration 270 days. Plants are robust,

			vigorous and taller
2	BSR.1	Clonal selection from Erode local irradiated with x rays	Bright yellow rhizome, curcumin 4.2%, oleoresin 4.0%, essential oil 3.7%, dry recovery 20.5%, crop duration 285 days, suitable for drought prone areas of Tamil Nadu.
3	BSR.2	Induced mutant from Erode local	A high yielding short duration variety (245 days) with bigger rhizomes, resistant to scale insects
			Maharashtra Agrl. University, Kasba, Digraj
4	Krishna	Clonal selection from Tekurpeta collection	Plumpy rhizomes, curcumin 2.8%, oleoresin 3.8%, essential oil 2.0%, dry recovery 16.4%, duration 240 days. Moderately resistant to pests and diseases.
Spices Research Station, GAU, Jagudan			
5	Sugandham	Clonal selection from germplasm	Thick, round rhizomes with short internodes. Curcumin 3.1%, oleoresin 11.0%, essential oil 2.7%, dry recovery 23.3%, duration 210 days. Moderately tolerant to pest & diseases.
			High Altitude Research Station, OUAT, Pottangi
6	Roma	Clonal selection from T.Sunder	Suitable for both rainfed and irrigated condition. suitable for hilly areas and late season planting. Curcumin 6.1%, oleoresin 13.2%, essential oil 4.2% and dry recovery 31.0%, duration 250 days.
7	Suroma	Clonal selection from T. Sunder by x- ray irradiation	Round and plumpy rhizome, field tolerance to leaf blotch, leaf spot and rhizome scale, curcumin 6.1%, oleoresin 13.1%, essential oil 4.4% and dry recovery 26.0%, duration 253 days.
8	Ranga	Clonal selection from Rajpuri local	Bold and spindle shaped mother rhizome, suitable for late planting and low lying areas. Moderately resistant to leaf blotch and scales, curcumin 6.3%, oleoresin 13.5%, essential oil 4.4% and dry recovery 24.8%, duration 250 days.
9	Rasmi	Clonal selection from Rajpuri local	Bold rhizomes, suitable for both rainfed and irrigated condition, early and late sown season, curcumin 6.4%, oleoresin 13.4%, essential oil 4.4% and dry recovery 23.0%, duration 240 days.
Tirhut College of Agriculture, RAU, Dholi			
10	Rajendra Sonia	Selection from local germplasm	Bold and plumpy rhizome, grows widely under all north Indian conditions. Curcumin 8.4%, essential oil 5.0% and dry recovery 18.0%, duration 225 days.
ICAR R.C. NEH Region, Shillong, Meghalaya			
11	Megha turmeric-1	Selection form Lakadong type	Suitable for the North East hill and North West Bengal. Bold rhizomes, high curcumin content 6.8% and dry recovery 16.37%, duration 300-315 days.
UBKVV, Pundibari			
12	Suranjana	Clonal selection from local types of West Ben gal (TCP-2)	Suitable for open and shaded conditions, sole or intercrop, suitable for rainfed as well as high rain fall areas. Curcumin 5.7%, oleoresin 10.9%, essential oil 4.1%, dry recovery 21.2%, duration 235 days, tolerant to leaf blotch and rhizome rot. Resistant to rhizome scales and moderately resistant to shoot borer.
IISR, Kozhikode			
13	Suguna	Selection from germplasm collected from Assam	Short duration type (190 days), curcumin 4.9%, oleoresin 13.5%, essential oil 6.0% and dry recovery 20.4%, field tolerance to rhizome rot.
14	Suvarna	Selection from germplasm collected from Assam	Bright orange coloured rhizome with slender fingers. Maturity 200 days, field tolerant to pest and diseases Curcumin 4.3%, oleoresin 13.5%, essential oil 7.0% and dry recovery 20.0%.
15	Sudharsana	Selection from germplasm collect from Singhat, Manipur	High yielding variety, short duration type (190 days). Field tolerant to rhizome rot. Curcumin 5.3%, oleoresin 15.0%, essential oil 7.0% and dry recovery 20.6%.
16	IISR Prabha	Open pollinated progeny selection	High yielding variety, curcumin content 6.5%, oleoresin 15.0%, essential oil 6.5% and dry recovery 19.5%, crop duration 205 days.
17	IISR Prathiba	Open pollinated	High quality line, 6.2% curcumin content with high yield, 16.2%

		progeny selection	oleoresin, 6.2% essential oil, 18.5% dry recovery, crop duration 225 days.
18	IISR Alleppy Supreme	A clonal selection from Alleppy turmeric	Shows tolerance to leaf blotch disease. Rhizomes contain 5.55% curcumin, 16.0% oleoresin, 19.0% dry recovery, crop duration 210 days
19	IISR Kedaram	Clonal selection from Thodupuzha collection	Tolerant to leaf blotch disease, Rhizomes contain 5.5% curcumin, 13.6% oleoresin, maturity 210 days and 18.9% driage.
College of Hort., KAU, Vellanikkara, Trichur			
20	Kanthi	Clonal selection from Mydukur variety of Andhra Pradesh	Erect leaf with broad lamina, big mother rhizomes with medium bold fingers and closer internodes. Medium duration. Curcumin content (7.18%), oleoresin 8.25%, essential oil 5.15%, dry recovery 20.15%, duration 240-270 days.
21	Sobha	Clonal selection from local type germplasm	Mother rhizome big with medium bold and closer internodes. Inner core of rhizomes is dark orange like Alleppey. More territory rhizomes. Dryage 19.38%, curcumin content (7.39%), oleoresin (9.65%), essential oil (4.24%), medium duration 240-270 days.
22	Sona	Clonal selection from local germplasm	Orange yellow rhizome, medium bold with no territory fingers. Best suited for central zone of Kerala. Rhizome medium bold, field tolerant to leaf blotch. Curcumin 7.12%, essential oil 4.4%, oleoresin 10.25%. 18.88% dry recovery, medium duration. 240-270 days.
23	Varna	Clonal selection from local germplasm	Bright orange yellow rhizome, medium bold with closer inter nodes, territory fingers present. Suited to central zone of Kerala. Field tolerant to leaf blotch, curcumin 7.87%, essential oil 4.56%, oleoresin 10.8%. 19.05% dry recovery, medium duration 240-270 days.
Navsari Agricultural University, Gujarat			
24	GN turmeric 1	Clonal selection form Maharashtra collection	Yield 23.37 t/ha, compact rhizomes, high number of fingers per rhizomes
Punjab Agricultural University, Ludhiana			
25	Punjab Haldi 1	Clonal selection	Average yield 27.2 t/ha, maturity 215days
26	Punjab Haldi 2	Clonal selection	Average yield 30 t/ha, maturity 238 days
CSK Himachal Pradesh Agricultural University, Solan			
27	Palam Pitambar	Clonal selection	High yielding, average yield 33.2 t/ha, curcumin 5%, essential oil 7 %
28	Palam Lalima	Palam Pitambar	High yielding, average yield 35.7 t/ha, curcumin 7%

(Singh et al. 2009)

Conservation

Collection and conservation of genetic resources of turmeric were given maximum importance in India. In addition to Indian Institute of Spices Research (IISR), Calicut good collections of turmeric germplasm are also maintained at various research centers. An *in vitro* gene bank of important genotypes is also maintained at IISR and National Bureau of Plant Genetic Resources, New Delhi (Tyagi *et al.* 1998, Geetha, 2002). *Ex-situ* genebanks of turmeric were established in IISR, Calicut and NBPGR, Regional Station, Trichur by conducting extensive survey to important turmeric growing areas in the country. Turmeric germplasm maintained under various centers are listed in Table 14.

Table 14. Turmeric germplasm collections in NARS centres

Center	Cultivated	Wild and related sp.	Total
Calicut	1200	70	1270
Pottangi	199	-	199
Jagtial	273	-	273
Dholi	90	2	92

Raigarh	42	3	45
Kumarganj	130	-	130
Pundibari	152	18	170
Solan	125	-	125
Coimbatore	273	2	275
Pantnagar	16	-	16
Pasighat	45	2	47
Total	2500	95	2595

(AICRPS, Annual Report, 2009-10)

By utilizing these germplasm, 22 varieties with high yield, pest/disease resistance and quality attributes have been developed and released for cultivation at various agro-climatic regions of the country.

Conclusion

Understanding the genetic structures of the species is a prerequisite to undertake any successful conservation program, because species that lack adequate genetic variations are at greater risk of extinction and the existing levels of genetic variations and the maintenance of these variations are the major issue for plant genetic diversity conservation. Conservation of genetic resources of spices assumes priority in view of the changing climatic and edaphic factors, depletion of forest areas, wide spread use of few cultivars etc. However, efforts are going on at various organizations in the country to conserve the biodiversity of these species and also utilize them in respective crop improvement programs.

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Genetic and varietal diversity and its conservation – Tree spices

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Tree spices are a unique group by its perennial nature, large canopy and multiple uses than other spices. Accordingly to Rema et. al. (1972) seventeen tree spices are grown in different parts of India, which are presented in Table 1.

Table 1. Tree spices grown in India

Sr. No.	Botanical name	Family	Common name	Part used as spices
1	*Averrhoa bilimbi* L.	Averrhoaceae	Bilimbi	Fruit
2	*A. carmbola* L.	Averrhoaceae	Carambola	Fruit
3	*Cinnamomum aromaticum* Nees	Lauraceae	Chinese cassia	Bark, leaf
4	*C. tamala* Nees	Lauraceae	Tejpat, Indian cassia	Leaf, bark
5	*C. verum* Bercht & Presl.	Lauraceae	Cinnamon	Bark, leaf
6	*Garcinia gummi-gutt*a (L.)Robs.	Clusiaceae	Garcinia, Cambogia	Pericarp of fruit
7	*G. indica* (Thouars) Choisy	Clusiaceae	Garcinia, Kokam	Pericarp of fruit
8	*Illicum verum* Hook	Illiciaceae	Star anise	Fruit
9	*Juniperus communis* L.	Cupressaceae	Juniper	Fruit
10	*Laurus nobilis* L.	Lauraceae	Bay leaf	Leaf
11	*Mangifera indica* L.	Anacardiaceae	Mango	Rind of immature fruit
12	*Murraya koenigii* (L.) Sprengel	Rutaceae	Curry leaf	Leaf
13	*Myristica fragrans* Houtt.	Myristicaceae	Nutmeg	Kernel, Aril
14	*Pimenta dioica* (L.) Merr.	Myrtaceae	Allspice, Jamaica pepper	Immature fruit, Leaf
15	*Punica granatum* L.	Punicaceace	Pomegranate	Dried seed (with flesh)
16	*Syzygium aromaticum* (L.) Merr. & Perry	Myrtaceae	Clove	Flower bud
17	*Tamarindus indica* L.	Caesalpiniaceae	Tamarind	Fruit

Among the various tree spices, nutmeg, tamarind, clove, cinnamon, kokum are of commercial importance in India. India exports & simultaneously import considerable amount of tree spices.

Nutmeg

Nutmeg belongs to family Myristicaceae with about 18 genera and 300 species. The species of the genus *Myristica* are distributed from India and South East Asia to North Australia and the Pacific Islands. Apart from *M. fragrans* about 12 different spices are reported from India *viz*., *Myristica amygdalina* Wall, *M. andamanica* Hook, *M. attenuate* Wall, *M. dactylodies* Goertn, *M. gibbosa* Hook, *M. glabra* Blume, *M. glaucescens* Hook, *M. irya* Gartn, *M. kingii* Hook, *M. longifolia, M magnifica* Beddome, *M. malabarica* Lamk (Haldankar et, al., 2008). However, only *M. fragrans* posseses economic potential and the use of other spices is restricted for rootstock.

Nutmeg is dioecious in nature and considerable variation is observed in present nutmeg population with respect to duration of anthesis and fruit set (Haldankar et. al., 2004). Krishnamoorthy et. al., (1996) found that the fruit weight of nutmeg ranged from 60.5 to 80.0 g, the seed weight from 8.4 to 12.2 g and the mace weight from 2.5 to 3.7 g under Kerala conditions. The present crop improvement programme is restricted to selection of high yielding nutmeg types with good quality nut and mace. The following varieties have been released by various Institutes for commercial cultivation of nutmeg (Table 2).

Table 2. Important characteristics of nutmeg varieties

Sr. No.	Name of variety	Institution	Special characters
1	Konkan Sugandha	Dr. B. S. K. K. V, Dapoli	Tree bears Male & female flowers on same plant, Higher fruit set, Medium size nuts (5 g), High yielder (500 fruits / tree / year).
2	Konkan Swad	Dr. B. S. K. K. V, Dapoli	Female plant, Higher percentage fruitset, Medium size nut (5.8 gm), High yielding (700-750 fruits/tree/year).
3	Konkan Shrimanti	Dr. B. S. K. K. V, Dapoli	Female plant, Higher percentage fruitset, Thick mace (2.10 g) Big size nut (10.0 g).
4	IISR Viswashree	Indian Institute of Spices Research, Calicut, Kerala	4800 kg mace/ha, at 25^{th} year 31,220 kg dry nuts / ha, 480 kg mace / ha, at 8^{th} year 3,122 kg dry nuts / ha.

Nutmeg posseses great potential as a main crop as well as a mixed crop in coconut plantations. The demand for nut and mace are increasing. The pericarp provides opportunities for novel value addition. Considering future scope it is necessary to conserve elite types *in situ* and *ex situ*. Presently *in situ* conservation at various centers at IISR, Calicut, DBSKKV, Dapoli and TNAU, Pechiparai (Tamil Nadu) are made.

Clove (*Syzygium aromaticum* L.) Merr & Perry

Clove belongs to genus *Syzygium* with about 500 species. The genus *syzygium* is closely related to Eugenia. *Eugenia* is now restricted to New Word Texa while all Asiatic species are included in *syzygium*. The genetic base of clove in India is narrow because of few original introductions.

Considerable variation for 15 petiole and midrib characters in cultivated and wild populations from clove in India were noticed, but unsufficient to distinguish clearly between types (Jarvie and Koerniati, 1986). Flower bud characteristics in clove were most useful in distinguishing between populations (Pool et al., 1986). Systematic germplasm surveys for clove types were undertaken by IISR and a dwarf variant of Kanyakumari district of Tamil Nadu was identified. In India generally local types are under cultivation and no true variety of clove is recognized. Three forms of clove have been identified with following description.

a. The buds hardly red when ripe
b. The buds red when ripe
c. White fruit (female clove): - hardly red when fit for gathering

So far, the clove types are conserved *in situ* at IISR, Calicut, DBSKKV, Dapoli (Maharashtra) and TNAU, Pechipari (Tamil Nadu). Seeds stored in closed polythene bags at 30^0C were found to be a suitable germplasm repository (Anilkumar et. al., 2000)

Cinnamon (*Cinnamomum verum* Bercht & Presl.)

Cinnamon belongs to family lauraceae which consists of 11 genus and about 250 species (Willis, 1973). It is distributed in South East Asia, China and Australia (Mabberly, 1987) growing mainly in tropical rain forest at various atltitute. In India, 26 species are reported (Hooker, 1886). Based on leaf morphology, bark pungency, grittiness of bark and leaves, 8 different types of cinnamon are reported in Shrilanka.

In cinnamon types, high variation for dry and fresh bark yield per plant, bark oleoresin, leaf oil, leaf size index and percentage recovery of bark has bean reported. Correlation and path analysis studies indicated that fresh leaf yield, leaf oil yield and euqenol yield were highly correlated among themselves (Joy et, al., 1998). Significant variability of bark oil content in cinnamon germplasm is reported (Krishnamoorthy et, al., 1998). The crop improvement work in cinnamon is limited to selection of high bark and leaf yielding cinnamon types with high quality. The following cinnamon varieties have been released by various Institutes in different parts of India (Table 3).

Table 3. Important characteristics of cinnamon varieties

Sr. No.	Name of variety	Institution	Special characters
1	IISR Navashree	Indian Institute of Spices Research, Calicut, Kerala	200 kg dry quills/ha, Bark oil 2.7 %, Leaf oil 2.8 %, bark oleoresin 8.0%, Bark recovery 40.6%
2	IISR, Nithyashree	Indian Institute of Spices Research, Calicut, Kerala	200 kg dry quills/ha, Bark oil 2.7 %, Leaf oil 3.0 %, bark oleoresin 10.0%, Bark recovery 30.7%
3	YCD – 1	Horticultural research Station, Yercaud. Salem District	360 kg dry bark/ha, Bark oil 2.8%, Leaf oil 3.0 %, Bark recovery 35.3%
4	PPI (C) 1	Horticultural research Station, Yercaud. District Salem	973 kg fresh bark/ha, Bark oil 2.9 %, Leaf oil 3.3 %, Bark recovery 34.22%
5	Konkan Tej	Dr. B. S. K.K. V, Dapoli	378.3 g fresh bark / plant, Bark oil 3.20 %, Leaf oil 2.28 %, Bark recovery 29.16%
6	RRL (B) C-6	Regional Research Laboratory, Bhubaneswar, Orissa	Leaf oil 0.8%.
7	Sugandhini (ODC – 130)	Aromatic & Medicinal Plants research Station, Odakkali, Kerala	1.2 kg fresh bark tree/year, Bark oil 0.94 %, Leaf oil 1.6 %, Bark recovery 51%
8	Konkan Tejpatta	Dr. B. S. K. K. V., Dapoli	Higher yield of leaves (1.94 kg/plant/year) and 80 g dried bark/ plant/year).

Garcinia

Garcinia is a large genus of family Clusiaceae which consists over 35 genera and 800 species (Gunaga et, al., 2010). In India, 36 species of *garcinia* are reported and approximately 30 species are cultivated and produce edible fruits. Among these various species are *Garcinia indica*, *G. mangostana, G. cambogia, G. gummi-gatta, G. morella, G. living stone, G. paniculata, G. cowa, G. hombroniana, G. ethenocarpa G. xanthochymus, G.lanceaefolia, G. dulcis.* Among all the *garcinia* species *Garcinia indica, G. combogia* and *G. cowa* are used as spice and condiment. Many species of Garcinia occure as a natural population and are known only locally. These species are threatened due to habitat distruction and some are almost extinct. At present the organized research programme for this precious group is lacking *Garcinia indica* and *G. combogia* are cultivated mostly at backyard of home.

Garcinia indica is dioecious in nature and hence wide variability with respect to morphological characters is reported. Remarkable variation with respect to fruit shape, size, yield and quality is reported in garcina species. The varietal improvement programme is restricted to selection of high yielding varieties and its multiplication. So far two varieties of *Garcinia indica* have been released for commercial cultivation (Table 4). The varietial characters of released varieties of *Garcinia indica* (kokum) is as under.

Table 4. Varietial characters of *Garcinia indica* (kokum)

Sr. No.	Name of variety	Institution	Special characters
1	Konkan Amruta	Dr. B. S. K. K. V., Dapoli	This is female tree, Early maturing, high yielding, apple shaped fruits, Longer shelf life, Good size (35 g), Average yield 4140 kg / plant / year.
2	Konkan Hatis	Dr. B. S. K. K. V., Dapoli	This is female tree, Bigger fruit size, Higher fruit weight (91.5 g), Thick peel (5.58 mm), Good keeping quality, Suited for processing. Average yield 250 kg fruits / tree / year.

(Nagwekar et. al. 2010)

At present the *garcinia* genotypes are conserved at various ICAR and SAU organizations in Western Ghats.

Allspice (*Pimenta dioica* (L.) Merr.)

Allspice is a unique tree spice, the flavour of which combines the flavour of clove, cinnamon and nutmeg. It is a polygamodioecious evergreen tree. It was introduced in India and trees are available in Maharashtra, Tamil Nadu, Karnataka and Kerala. Very little work with respect to its variability is reported. Though, few high yielding trees are available, no specific variety is recommended or released. Germplasm of allspices is being conserved at IISR, Calicut, DBSKKV, Dapoli (Maharashtra) and TNAU, Pechiparai (Tamil Nadu)

Curry leaf (*Murraya koenigii* (L.) Sprengel)

Curry leaf is native to India and found growing wild in the subcontinent. Large amount of variability is found in curry leaf with respect to plant height, leaf length, leaflet length main stem thickness and number of branches per plant, oil content and composition of essential oil (Lalitha et, al., 1997). Wide range of D^2 values were reported by Lal et al., (2003) for curry leaf accessions grouped into 7 clusters. So far DWD -1 (Suvasini) a clone of root sucker with dark green leaf and strong aroma and DWD – 2 a seedling progency with ashy green leaves and less aroma has been released by University of Agril. Sciences, Dharwad. However, the existing diversity in curry leaf has not been properly utilized.

Tamarind (*Tamarindus indica* L.)

Tamarind belongs to family Leguminosae sub family Caesalpinae. It exhibit remarkable variation for economically important traits (Gunasena Hughes, 2000). Variation for fruit character *viz* length of pod, pod weight, seed number, pod colour and sweetness of pulp is observed. Two major types of tamarind are recognized viz., sweet fruit and sour flavoured based on sweetness of fruit pulp. The improvement programme is confined to selection among the existing germplas (Table 5).

Table 5. Improved varieties of tamarind

Sr. No.	Name of variety	Institution	Special characters
1	DTS – 1	University of Agril. Sciences, Dharwad.	High yielding tree 56 kg pods/year (10th year) with high tartaric acid (17.03%).
2	DTS – 2	University of Agril. Sciences, Dharwad.	High yielding tree 44.20 kg pods/year (10th year) with high tartaric acid (14.73%).

Conclusions

Tree spices are a prospectus group of spices having enormous potential as mono crop mixed crop and house backyard crop. Considerable quantity of tree spices is imported in India. Among the tree spices in India nutmeg, clove, cinnamon and garcinia are of commercial importance. At present the crop improvement is restricted to selection of promising genotypes. Limited work with respect to survey, crop improvement in tree spices and its conservation has been done in tree spices. The organized research programme at ICAR or SAU level is lacking in precious tree spices like Garcinia. There is great scope to explore the variability and systematic crop improvement in tree spices

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Genetic diversity in herbal spices

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Most of the herbal spices are also aromatic oil yielding plants yielding essential oils used in flavour and fragrance industries. When the raw materials are used fresh in smaller quantities along with food they help in the culinary properties improving taste and imparting aroma to the food and also due to the pharmaceutical properties of the secondary metabolites present help in the health aspects. Though in India use of curry leaf, coriander leaf, pudina leaf is in vogue, parsley and other herbal spices are gaining importance. A number of other plants are used around the world (eastern, western and European countries). An attempt has been made to compile the research done in various herbal spices mostly on genetic diversity to benefit from the natural variability, to develop superior cultivars and conservation of genetic diversity in these crops.

Basil (*Ocimum basilicum* L.)

A popular culinary herb and its essential oils have been used extensively in the flavoring of confectionary and baked products, condiments (e.g., ketchups, tomato pastes, chili sauces, pickles, and vinegars), sausages and meats, salad dressings, nonalcoholic beverages, ice cream, and ices.

Intraspecific variation in the quantity and quality of the essential oils and quantitative and qualitative characters in different accessions of *Ocimum basilicum* was studied. The occurrence of the chemotypes rich in methyl chavicol, linalool, methyl cinnamate and geranyl acetate denoted chemical polytypism. Chemical studies revealed rosmarinic acid is the predominant phenolic acid present in both flower and leaf tissues. Unusual basil accessions were identified which can serve as genetic sources of phenolic acids for crop improvement. It was shown that there are no dissimilarities in chromosome number, ploidy level and satellite chromosomes. Chemical compounds of essential oils were found variable in the various basil cultivars in Italy and the plants were classified into main phenotypes and chemotypes (Thoppil and Jose, 1994 Jamal *et al*., 2002, Masi, *et al.,* 2006). Valtcho *et al*., (2008) reported significant variation among genotypes with respect to oil content and composition. Oil content of the accessions varied from 0.07% to 1.92% in dry herbage. The availability of various chemotypes gave an opportunity for production of basil to meet the market requirements of specific basil oils or individual compounds such as (−)-linalool, eugenol, methyl chavicol, methyl cinnamate, or methyl eugenol.

Path coefficient analysis for oil yield in basil exhibited variation from season to season and slight variation was found among cuts. The highest direct effects on oil yield were observed for herb dry yield followed by stem dry weight and essential oil content; herb dry yield and essential oil content were recommended as selection criteria for improvement of oil yield in sweet basil (Ibrahim *et al*., 2011). Variability studies in 30 *Ocimum* genotypes (20 exotic and 10 indigenous) revealed highly significant variation for all the characters studied. The pooled data analysis revealed that fresh herbage yield per plant had highest positive direct effect with essential oil yield per plant and maximum direct negative effect in essential oil content. (Panwar *et al*., 2009).

Molecular and biochemical markers were extensively used to characterize the variability present in basil (Vieira *et al.,* 2003). RAPD analysis grouped 12 basil genotypes of Italy into two main clusters. One of these included cultivars suitable for food industry, which were also correlated via agro-morphological features (Masi, *et al.,* 2006). Mustafa *et al.,* (2006) studied seven populations of two species of basil in Egypt and constructed trees based on variation in morphological, seed proteins or isozyme data showing the existence of genetic diversity among and within populations that might be related to natural hybridization and fluctuations in environmental conditions. Molecular markers were also used to assess genetic diversity in different *Ocimum* spp (Varadaraj, *et al.,* 2006). The studies showed maximum similarity among *O. basilicum* cultivars.

Coriander *(Coriandrum sativum)*

Diversity studies were reported for the presence of molecular and essential oil diversity in Coriander. A high level of diversity was also obtained for essential oil yield, both herb and seed parts among twenty coriander landraces of Iran. 15 RAPD primers produced a total of 261 scorable RAPD loci, of which 90 were polymorphic (34.48%). Genetic similarity calculated from the RAPD data ranged from 0.294 to 0.740 with an average of 0.541 (Omidbaigi et al., 2009).

Multivariate analysis was used to study the variability pattern among coriander genotypes. Singh *et al*., 2003 studied the genetic association and distances in a collection of 15 Indian accessions consisting of 8 landraces and 7 cultivars, on the basis of seven economic plant traits including essential oil content and oil yield. The study revealed that genetic distance in the material was higher with the D^2 values ranging from 37.4 to 1309. The genetic diversity was found to be independent of the geographical diversity of the genotypes.

The population consisting of 40 genotypes was grouped into four clusters on similarities of their D^2 values. The inter-cluster D^2 values ranged from 0.62 to 30.7, suggesting considerable diversity among the groups (Srivastava *et al*., 2000). Patel *et al.,* (2000) used forty-eight genotypes collected from major coriander growing district-Guna (Madhya Pradesh) and grouped them into nine clusters using D^2 analysis. The clustering was at random and without any relationship between genetic diversity and geographic diversity. The above studies suggested that improvement in this crop would be possible by exercising selection for oil yield, seed yield and their associated traits, viz. oil content and umbellets per umbel, days to flowering, days to maturity and number of secondary branches^{-1}. The clustering pattern of strains did not follow the geographical distribution exactly.

Curry leaf (*Murraya koenigii* (L.) Spreng.),

Curry leaf plant belongs to family Rutaceae and is important for its leaves, oil and other parts of the plant which are used in traditional and indigenous systems of medicine and as foods. It is found in the different hilly regions of India. Genetic diversity was assessed using multivariate analysis and molecular markers. High genetic divergence (D^2=73.50-4353.75), potential genetic stocks were reported from 43 accessions of different eco-geographical origin in India. The enormous morphological variability was observed for leaf morphology, colour, and shape; bark-colour, fruits colour and morphology; seed morphology and odour value of the essential oil. All of the characters influencing oil content of plant were highly heritable (h^2_{BS} ranges from 84.37%-99.98%) 89.47% polymorphism among fifty-nine accessions representing eight wild populations were reported using thirteen ISSR primers. AMOVA and Nei's genetic diversity analysis revealed higher genetic variations within populations than among the populations. The clustering of populations in the dendrogram was not in congruence with geographical affiliations.

Fenugreek (*Trigonella foenum-graecum*)

Fenugreek belongs to family Papilionaceae. Two Trigonella species and 61 accessions were analyzed with 18 random primers to evaluate genetic diversity and species relation. There is almost no or very little intraspecific difference in morphological manifestations in elite cultivars of both species. The percentage of polymorphic band ranged from 66% to 100% with an average of 52.85%. Genetic similarity ranged from 0.66 to 0.90, indicating a moderate to high genetic variability (Sundaram and Purwar, 2011).

Marzougui *et al. (*2004) reported 60.5% of polymorphism in 38 Tunisian cultivars using 12 ISSR markers. UPGMA dendrogram presented five cultivar clusters. Principal components analysis confirmed this clustering and showed the same five clusters that were obtained by UPGMA analysis. Genetic distances were not correlated with geographic distances (r=0.04 and p=0.366 > 0.05) but the majority of the cultivars were localized in the upper semi arid stage.

Me Cormick *et al*., (2009) recorded significant variation for a range of phenotypic traits in 205 fenugreek accessions evaluated in the field in south-eastern Australia. The accessions identified as from the sub species *indica* Sinsk. had small, yellow seed and originated mainly from Pakistan and India and half of these types had significantly higher yields than the check-line. Accessions that fitted the description of the more diverse sub sp. *foenum-graecum* were from Iran, Afghanistan, Turkey and several northern African countries, and there were high yielding green-seeded types in this group. Accessions from Turkey and Iran showed the most phenotypic diversity.

Genetic diversity parameters were calculated for ISSR, RAPD and ISSR+RAPD approaches in Seventeen accessions of *Trigonella foenum-graecum* and nine accessions of *Trigonella caerulea* (Dangi *et al*., 2009). Plants from different geographical regions were distributed in different groups in both the species. Based on genetic similarity indices, higher diversity was observed in *Trigonella caerulea* as compared to *Trigonella foenum-graecum*. The genetic similarity matrices generated by ISSR and RAPD markers in both species were highly correlated (r=0.78 at p=0.001 for *Trigonella foenum-graecum* and r=0.98 at p=0.001 for *Trigonella caerulea* indicating congruence between these two systems.

More than 170 collections of both species from India and 15 other countries were evaluated for 24 morphological, agronomic or physiological traits. Collections from Himachal Pradesh, India, showed the widest range of variation while those from Uttar Pradesh showed promise for high yield. Foreign collections displayed wide variation for seed size and contained more diosgenin than the Indian material (Pant *et al*., 1983). Jain *et al*., (2006) evaluated thirty-six genotypes of Rajasthan and grouped them into 6 clusters for genetic divergence following D^2 analysis. No significant relationship was observed between genetic diversity and geographical diversity. Among the 10 characters evaluated for genetic divergence, fat content had the greatest effect (70.3%) on the total divergence, followed by plant height (8.6%).

Lavender *(Lavandula multifida* L.*)*

Hnia and Mohammed (2011) assessed the genetic variation within and among eight Tunisian natural populations of lavender from different bioclimatic zones using RAPD markers. The genetic diversity within a population was high and varied according to the populations (0.308<H'<0.459) without relationships to altitudes or pluviothermic indices of sites. The genetic differentiation among populations was high (G_{ST}=0.395 and Phi $_{ST}$=0.318). The neighbor-joining cluster analysis showed that individuals from each population clustered together. UPGMA cluster analysis showed that population groupings are not strictly in accordance with bio-climates or geographic location. The genetic differentiation in *L. multifida* could have occurred at local scales because of genetic drift.

The genetic diversity and population structure of 20 Tunisian *Lavandula stoechas* L. and *Lavandula multifida* L. populations, from different bio-climates, were analysed by seven isozymes. Variation in *L. multifida* was higher than that observed for *L. stoechas*, and exclusive alleles were detected for taxa. A high differentiation among populations, for each species, estimated by Wright's *F*-statistics was revealed. The UPGMA cluster analysis of genetic distance values revealed that populations for each species were not strictly clustered together according to bio-climate or geographic proximity. The dendrogram generated from pair-wise genetic distance among all populations showed two distinct clusters each corresponding to one species (Chograni *et al*., 2008).

Origanum (*Origanum vulgare* L.)

Origanum is a spice and medicinal herb that is characterized by high morphological diversity. The relative efficiencies of two PCR-based marker approaches, AFLP and SAMPL were used for comparable genetic diversity surveys and subspecies discrimination among 42 oregano accessions. The results indicate that both marker systems are suitable but SAMPL markers are slightly more efficient in differentiating accessions and subspecies than AFLPs (Ayanoglu *et al*., 2006 A).

Amplified Fragment Length Polymorphism (AFLP) analysis was used to estimate genetic diversity within the oregano germplasm collection of Turkey. Forty-four *Origanum* accessions were analysed with ten *Eco* RI-*Mse* I primer combinations. Seven main groups were identified by the UPGMA clustering and there was no close genetic similarity among accessions related to their growing region. Relatively low genetic similarity (0.396-0.725%) between accessions indicated that the rate of gene flow between *Origanum* species was high, as a result of cross-pollination (Ayanoglu *et al*., 2006 B).

The genetic variation between and among 14 populations from Jordan were analyzed using 48 RAPD primers. Similarity values among the studied populations and accessions ranged from 0.85 to 0.000. Based on a dendrogarm *O. majorana* species showed a separated group and the cluster analysis clearly differentiated between *O. syriacum* and *O. majorana*. Presence of genetic variation among and within two species of *Origanum* indicated that Jordan had a wide genetic diversity.

Akeel *et al*., (2009) characterized fourteen Turkish oregano (*Origanum onites* L.) clones chemically and genetically. Genetic variation was determined by use of RAPD markers. Two chemotypes, carvacrol and thymol, were identified. The oregano clones were divided into three main groups by clustering on the basis of RAPD markers. Genetic similarity values among the oregano clones ranged between 0.49 and 0.73 which was indicative of a low level of genetic variation The results also indicated that there is no relationship between genetic structure of the selected clones and essential oil composition.

Peppermint (*Mentha piperita* L.)

The genetic analysis by ISSR molecular marker technology showed 96.59% polymorphism among 11 genotypes of *Mentha* of china. Cluster analysis showed that the 11 cultivars could be distinctively classified into 4 groups. Studies on the morphological and genetic variations of different mint species showed that they differ significantly from one another, both in relation to the analysed morphological and genetic features. A series of species-specific ISSR products were identified. Phylogenetic similarity of the compared species varied from 53.3% between *M. piperita* and *M. aquatica* to 82.2% between *M. suaveolens* cv. Variegata and *M. spicata* var. *crispa*.

A total of 37 clones of *M. piperita* cv. Kukrail revealed remarkable variations for the 9 plant traits (plant height, leaf:stem ratio, herb yield and contents of oil, menthol, menthofuran, menthyl acetate and menthone). the 37 clones could be classified into 2 classes: menthol- and menthofuran-rich genotypes

Eighteen accessions of *Mentha arvensis* var. *piperascens* showed wide range of compositional differences in the essential oil profile. Morphological characters, oil yield and essential oil components were taken into account to generate a cluster that out grouped divergent genotypes. High genetic variability among 17 accessions of four *Mentha* species (*Mentha spicata, M. longifolia, M. piperita* and *M. suaveolens*) was reported. Similarity value ranged from 13.24 to 68.8%, with a mean of 0.25. Two major clusters were distinguished by RAPD markers. In the view of taxonomists and studies on the evolution of the mints, *M. piperita* is believed to be a hybrid between *M. spicata* and *M. aquatica*. It was reported that cultivars with higher chromosome numbers showed more vigorous growth, accelerated generative development, increased essential oil content, and changes in essential oil composition (higher contents of menthone, isomenthone and limonene, and lower contents of menthol, menthofuran, 1,8-cineole [eucalyptol] and viridiflorol), compared with cultivars with lower chromosome numbers.

Morphological, molecular diversity and oil quality characteristics were investigated in fifteen elite accessions of *M. spicata*. These genetic and morpho-chemical clusters were compared for relatedness and differences. It was observed that RAPD analysis for the phylogenetic relationship was a better indicator of descendency and origin among the germplasm accessions. The comparative oil component analyses of 20 Indian peppermint accessions revealed the close relation of P4 and P5 (Indian collections) with Chinese and P9 to Japanese peppermint. Some of the analysed samples (P6, P8, P11 and P17) were close to American, Canadian, European and South African oils. Essential oil profiles of Indian accessions P10, P14, P19 and P20 were quite different from others as revealed by component plot analysis. In addition to the similarities, distinct chemotypes in the germplasm were detected with unique essential oil component profiles. Amplified fragment length polymorphism (AFLP) analysis differentiated them genetically with a diversity ranging between 17-95%.

***Rosemary** (Rosamarnus officinalis L.)*

Rosemary belonging to family labiatae is an evergreen shrub that has been cultivated throughout time for its lovely fragrance. It is a native of southern Europe. Boussaid *et al*. (2006) reported substantial genetic diversity among three Tunisian Lamiaceae species, *Rosmarinus officinalis*, *Lavandula multifida* and *Thymus algeriensis*, using alloenzyme electrophoresis. Only *R. officinalis* showed a significant relationship between population structure and geographic distance. Intraspecific populations' genetic similarity was high.

A high genetic diversity due to the species mating system and the large size of populations before fragmentation within population was revealed by isozymes and essential oil variations from 14 Tunisian natural populations of *Rosmarinus officinalis* L. using eight isozymes and 25 terpenoids. Essential oil composition varied among populations. Genetic and chemical data were highly correlated (Zaouali and Boussaid2008).

Wellwood and Rosemary (2004) developed methods to identify and select accessions of rosemary, *Rosmarinus officinalis* (L.), and reported variation of carnosic acid concentrations in extracts of 29 accessions. Varela *et al.,(.*)reported a negative significant correlation between the concentration of essential oil and the altitude with a $p < 0.05$ in populations of *R. officinalis* from the Spanish regions. Among all samples, 38 of them had high 1.8-cineol (>24%) content and high yield of essential oil (>2%), 6 of them showed high 1.8-cineol/linalool and 3 samples had high linalol content. Two samples from Andalucia gave high content in verbenona (5.49, 5.37%).

Sage (*Salvia officinalis)*

The genetic pattern and volatile oil composition of clones of various geographical origins (nine from Italy and one from Albania) were determined by RAPD analysis. Banding patterns obtained confirmed the distinct genetic variability between *S. officinalis* and *S. fruticosa* and among the various clones of *S. officinalis*. *S. fruticosa* was differentiated from *S. officinalis* on the account of its high 1,8-cineole [eucalyptol] and low thujone content. *S. officinalis* plants formed three clusters: the first was characterized by medium 1,8-cineole level (9.5-18.8%), high alpha -thujone content (38.3-47.2%), and low camphor content (0.9-3.4%); the second by low 1,8-cineole level (3.1-3.9%), medium alpha -thujone level (28.7-39.4%), and medium camphor level (5.0-5.6%); and the third by high camphor content (17.5%). The Albanian clone was generally intermediate in terpene content.

The essential oil composition and genetic variability of common sage (*Salvia officinalis* L.) and its three ornamental cultivars were analyzed by GC-FID, GC-MS, and RAPD. Common sage and its cultivars contained the same volatile compounds; only the ratio of compounds differed. The main compounds were the sesquiterpene alpha -humulene and the monoterpenes beta -pinene, eucalyptol, and camphor. Judean sage contained mainly the sesquiterpenes beta -cubebene and ledol. All of the samples exhibited characteristic RAPD patterns that allowed their identification. Cluster analyses based on oil composition and RAPD markers corresponded very well to each other, suggesting that there is a strong relationship between the chemical profile and the genetic variability.

Thyme (*Thymus vulgaris*)

Thyme is indigenous to the Mediterranean with many species coming from an area that encompasses southern Europe, western Asia and North Africa. High levels of out-crossing and chemotype variation were found in disturbed environments, indicating greater genetic diversity. Chemotype composition of thyme populations was closely correlated with soil type, than that shown by populations in more stable environments (Gouyon *et al*., 1986). Pank, Kruger (2003) investigated the variation of the growth height (growth), bush volume (bush), content of essential oil (oil) and oil components between and within 13 thyme populations in the 1st and 2nd year of cultivation. The populations showed significant differences in most traits in both years. Chemotypes were readily distinguishable in collections of thyme populations and can be easily selected. Chizzola *et al.*, (2005) defined seven chemotypes based on the main compounds of the oil. Additionally, many populations consisted of heterogeneous plants of several chemotypes. In many populations, for a given chemotype, the main oil components displayed coefficients of variation between 10 and 25%. This observation of the high variability in the essential oil of thyme is an adequate basis for the development of lines and cultivars with a well defined chemical profile suitable for various purposes and uses.

The comparison of the oil components concentration by multivariate analysis allowed the separation of cultivars into two groups. On the basis of the RAPD patterns, the cultivars could be divided into two clusters, which coincide with results obtained by oil GS-MS analysis, with a correlation coefficient of -0.779 (Echeverrigaray 2001). Ma Li (2009) reported 91.84% polymorphism among 7 cultivars of thyme by ISSR technology. The genetic similarity among the 7 cultivars distributed between 0.34 and 0.76. Cluster analysis showed that the 7 cultivars were divided into 3 groups based on the coefficient of 0.51.

Conclusions

Herbal spices are being employed by food industry for flavor and fragrance purposes but are also important from health and probiotic point of view. Except curry leaf and coriander many of the above mentioned herbal spices are important from the point of melting of different cultures in the global village concept. Though lot of morphological variability has been reported the same is confirmed from use of DNA markers such as RAPD and ISSR giving hope for selection of chemotypes which hold promise. Efforts are needed for systematic study and exploitation of herbal spices in Indian context.

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Genetic diversity and conservation in coriander

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We would like to start the article with a statement "One man changed it all. Jan Huygen van Linschoten's hunger to know, passion for making elaborate notes, flair for detailed descriptions, faith in pictographic representation, and belief in a map that could say in one page what a man learns in an entire lifetime, changed this world forever" (http://blog.mapsofworld.com/2011/05/11/linschoten-spice-map-colonization).

Indeed the course of this world was always changed by single events or the persons. Had it not been for the Linchoten, the orient would not been exploited. This does not mean saying that businesses particularly related to spices would not have happened. The businesses with the central Asia and Europe were happening through what is known as silk routes and spice routes. The business was mainly for high value tree spices like cinnamon. Common sayings from ancient Europe that "he who controls the spice, controls the universe", "the spice must flow" or "No man should die who can afford cinnamon" all epitomize the importance the spices had in ancient trade and also the reason why sailor's set sail to invent new routes to India and in the process have ended up discovering new continents. Although it is not to bring forth historical importance of spices and India had in ancient times, our aim is to link history to the topic of this writeup. Seed spices have not originated in India. Let us examine coriander as a case. Vavilov (1992) reported coriander to have originated in central Asia, the Near East and Abyssinia. On the other hand four distinct regions namely (i) India, (ii) North America, (iii) Central Asia and (iv) Abyssinia were recognized as cradles of distinct types where different types of coriander have developed (Ivanova and Stoletova, 1990). In a detailed study of different collections obtained from different countries in coriander, Diederichsen (1977) noted differences in the specific morphological characters among different collections obtained from different countries. He has proposed probable route of diversity in coriander as given in Figure 1. Nevertheless, India have several regions which can be classified as diversity rich regions for these crops (Gangopadhyay, Yadav and Karihaloo, 2005) (
1).

Table 1. Seed spice crops and their centre of origin

Seed Spices	Centre of origin	Distribution
Major group		
Coriander	Mediterranean region	India, Morocco, Russia Bulgaria, Mexico, Argentina, China, Romania, Japan, Italy
Cumin	Mediterranean region	India, Turkey, Iran, Egypt, Pakistan, Syria, Italy
Fennel	South Europe and Mediterranean region	India, Egypt, China, Romania, Russia
Fenugreek	South East Europe and West Asia,	India, Morocco, Bulgaria
Minor group		
Ajowain	Mediterranean region and South West Asia	India, Iran, Egypt, Afghanistan
Dill	Europe, Africa and Asia	India, Germany, Hungary, Netherlands, Pakistan and USA
Celery	Mediterranean region	India, Southern France, China and Egypt
Aniseed	Eastern Mediterranean	Bulgaria, Cyprus, Germany, Russia and India

	region	
Nigella	Eastern Mediterranean	India, Pakistan, Sri Lanka, Bangladesh, Nepal, Iraq, Egypt

Plant breeding is all about crop improvement. The improvement is for yield of the economic part, or any other character that the crop plant possesses which has importance for the man who ultimately uses it. Any plant breeding programme starts with a collection of germplasm and its evaluation, because the evaluation of germplasm actually guides the plant breeders the course of action for the improvement. Centres of diversity of a crop are expected to have the maximum diversity. A map of possible centres of origin of spices is given in Figure . In many a cases the crop is introduced to a secondary area and there because of its adaptation new variation generates and thus these secondary centres are also important for the collection missions. The major as well as minor seed spices have mostly originated in Mediterranean region (Vavilov, 1951, 1926) (Table *1*2). India received these crops as introductions primarily through Arab invaders or through the traders of the old silk and spice routes (Fig. 2). Hence, the variation found in India is always expected to be limited in comparison to primary centres of origin.

Table 2. Diversity rich areas of seed spices in India (from Gangopadhyay, Yadav and Karihaloo, 2005)

Spice	**State**	**District/ Zone**
Coriander	Rajasthan	Baran, Bundi, Jaipur, Alwar, Sikar, Kota, Jhalawar, Chittorgarh
	M.P. & Chattisgarh	Guna, Rajgarh, Mandsoar
	Andhra Pradesh	Kurnool, Cuddapah, Ananthapur
	Tamil Nadu	Trichy
	Gujarat	Dantiwada, Junagadh
Cumin	Gujarat	Banaskantha, Mehasana
	Rajasthan	Jalore, Barmer, Nagaur, Ajmer, Pali, Tonk, Bhilwara, Jodhpur, Jaipur
Fennel	Gujarat	Sabarkantha, Mehasana
	Rajasthan	Sirohi, Tonk, Jodhpur, Ajmer, Bhilwara
Fenugreek	Rajasthan	Sikar, Chittorgarh, Jaipur, Pali, Jhalawar,
	Gujarat	Mehasana, Banaskantha
	M.P. & Chattisgarh	Jabalpur, Chattarpur, Indore
Ajowain	Gujarat	Mehasana, Banaskantha, Sabarkantha
	Rajasthan	Chittorgarh, Pratapgarh, Udaipur, Nimbahera, Jhalawar
	M.P. & Chattisgarh	Mandasaur, Ujjain, Indore
Celery	Punjab	Amritsar, Gurdaspur, Jalandhar
	Haryana	Panipat, Yamunanagar
	U.P.	Saharanpur
Nigella	U.P.	Kanpur, Unnav, Faizabad
	M.P. & Chattisgarh	Jabalpur, Chattarpur, Rewa
Aniseed	U.P.	Lucknow, Kanpur
	Rajasthan	Abu Road
	Gujarat	Unjha, Nadiad

Germplasm evaluation helps in knowing the worth of germplasm collection as well as the diversity found in germplasm. Any germplasm collection is evaluated for two types of characteristics namely characterization data and evaluation data. In most of the other crops, clear and elaborate internationally standardized descriptors are available for describing the entries in a collection. This is still lacking in seed spices. Where such documentation is available, is limited only to certain morphological traits and even the description is vague and ambiguous. One thing is striking, the resistance against diseases and pests is very limited or absent.

In order to evaluate the germplasm, valid descriptor lists are a prerequisite (Thomas and Mathur, 1991). A minimal descriptor list for major seed spices was prepared by All India Coordinated Spices and Cashewnut Improvement project (Sastry et al, 2011) which was later succeeded by an effort has been made by NRCSS, Ajmer in preparing a descriptor list for the spices crops (Malhotra and Vashistha, 2006), however this list is incomplete and lacked many an important characters which may help in distinguishing the lines. In order to prepare a valid descriptor list understanding detailed morphology of the plant is essential. Let us understand this point by taking coriander as an example. In coriander, the leaf pattern changes as it grows. Five clear cut growth stages can be recognized (Choudhary, 1987). In a preliminary evaluation, variation with regard to growth stages was found in coriander (Sastry et al 2011).

Diderichsen (1977) noted infra specific variation in coriander obtained from different countries. He noted that the variation was with regard to plant morphology, leaf morphology and seed morphology. Based on the variation found in collections from different parts of the world he even proposed a possible path of travel from Mediterranean region to other parts of the world. This is quite possible, because of the geographical and isolation barriers new adaptations are created in a given species which take the shape of infra and in many cases inter specific variation. At S K N College of Agriculture we wanted to study the possible parameters of variation in germplasm collection in order to fine tune the descriptor list. Initial evaluation of the germplasm indicated variation in leaf morphology (Sastry et al 2011). Variation was also found for other morphological features. Based upon the leaf morphology four categories of leaf types were identified (Fig 2). In an evaluation of part of germplasm maintained at S K N College of Agriculture, Jobner, it was found that 11 lines exhibited type A, 165 lines exhibited type B and 13 exhibited type C and only 2 genotypes exhibited type D leaf morphology. Variation within each type was also noted. The data are presented in Table 3. As can be seen, leaf morphology is a good way of distinguishing lines, although most of the lines belonged to type B. variation in the plant morphology was also found. Preliminary evaluation of lines indicated that the plant plant morphology can be grouped into three types (Fig 3). Out of the three types, the prostrate types have more leafy character, hence is ideal for leaf harvest. Variation in the seed type was limited, except size variation. All the genotypes had Indian type seeds (ovate).

Table 3: Variation for leaf morphology in coriander germplasm (only a part of the germplasm maintained at S K N College of Agriculture, Jobner was evaluated).

Leaf character	parameter	Leaf type		
		A	B	C
Peduncle length (cm)	mean	4.17	4.11	4.58
	min	3.00	1.50	3.00
	max	5.50	6.20	6.50
	sd	0.86	0.91	1.06
Lamina length (cm)	mean	2.77	2.96	3.18
	min	2.00	1.80	0.50
	max	4.00	4.60	4.50
	sd	0.56	0.51	0.92
Lamina width (cm)	mean	2.27	2.41	2.25
	min	1.50	1.40	1.50
	max	3.60	3.50	3.20
	sd	0.60	0.45	0.45
Length/width ratio (cm)	mean	0.83	0.82	0.99

Leaf character	parameter	Leaf type		
		A	B	C
	min	0.67	0.38	0.43
	max	1.44	1.15	5.00
	sd	0.21	0.12	1.21

Based upon the above information and other published reports, the minimal descriptor list of coriander was modified under the chairmanship of the senior author (Anonymous, 2009). The list has 36 characters for the morphological characters, 6 disease and pest resistance characters.

An evaluation of a part of germplasm collection maintained at S K N College of Agriculture, Jobner was done using the modified descriptor list. 86 out of 90 had medium growth vigour. Variation for seed yield was found to be more and this is possible as it is affected by environment. The values of different morphological characters are presented in Table 4.

Table 4: Statistical parameters for certain morphological traits and seed yield

Variable	Mean	Std dev	Minimum	Maximum	Coeff. of variation
Seed yield (g/plant)	13.73	7.17	4.00	32.00	52.19
Days to flowering	75.38	4.66	65.00	82.00	6.19
Plant height (cm)	86.22	12.71	59.60	128.20	14.74
Sub branches per plant	9.95	3.99	3.20	20.40	40.09
Umbels per plant	17.41	7.24	7.00	45.80	41.55
Umbellets per umbel	4.98	0.60	3.60	6.80	11.97
Seeds per umbel	25.57	6.12	16.30	48.40	23.91

Evaluation of over 300 accessions of coriander including 26 exotic ones at Jobner revealed significant variability for days to flowering, branches/plant, plant height, umbels/plant, 1000 seed weight, seed yield/plant and volatile oil content (Sastry and Sharma, 2001) (Table 55). A wide range of variation was observed for all the morpho-physiological characters. Heritability and genetic advance was moderate to high for days to flowering, plant height, umbellets/plant and seed yield/plant. For other characters like branches/plant and umbels/ plant, heritability and genetic advance both were low.

Table 5: Range, Coefficient of Variation (CV), Heritability (h^2) and Genetic Advance (GA) in Coriander

Characters	Range	CV	h^2	GA
Days to Flowering	3.8-7.3	16.29	90.13	30.0
Branches/Plant	39.9-110.8	16.17	23.78	7.9
Plant Height (cm)	12.2-40.1	29.91	58.18	35.9
Umbels/Plant	19.6-134.0	44.22	8.23	7.5
Umbellets/Plant	19.6-134.0	52.77	19.59	21.3
1000-seedwt. (gm)	5.2-18.5	22.70	94.58	5.2
Seed yield/Plant (g)	0.88-5.4	54.45	19.01	21.3

Multivariate analysis of characters of 200 accessions showed that maximum genetic diversity among the accessions was contributed by crop duration followed by-plant height, branches/plant and seed weight (Gupta, 1982, Sharma, 1984). Sharma (1982) observed significant genetic divergence in germplasm even in seed characters, for example, seed weight, seed volume and volatile oil content were considered along with seed and straw yield.

Studies on association of different characters with yield, revealed that yield/plant was positively associated with umbels/plant, umbellets/plant and plant height (Sevda, 1980). Similarly. Gupta (1982) and Sharma (1984) observed that branches/plant, days to flowering. umbels/plant, seed/umbel were positively correlated with seed yield and negatively correlated with 1000-seed weight. Path coefficient analysis of the association by Sharma (1984) showed that umbellets/umbel, umbels/plant: branches/plant and 1000-seed weight had high direct effect on seed yield and hence must be considered while making selections.Further, Sastry *et al* (*1*989) noted that expression of yield as well as related characters was significantly affected by the environment. Obviously, the germplasm accessions need to be evaluated over different environments and/or locations before these are finally documented.

Conservation

Conservation of germplasm is of prime importance. The objective of conservation is to maintain a line with little deterioration of the genetic structure. The conservation strategy therefore depends on reproduction behavior. Coriander is cross pollinated. Further, the cross pollination is mediated through insects particularly bees. Thus effective pollination will depend on the bee population.

Since coriander is a cross pollinated, maintenance of germplasm is tedious. Breese (1989) summarized the following characteristics of cross pollinators which need to be kept in mind while maintaining them.

1. Most of the outbreeders have mechanisms which encourage outbreeding (which also include self-incompatibility); the populations are heterozygous and are heterogeneous.
2. The loss of heterozygous balance through inbreeding leads to a decrease in expression of those characters showing directional dominance and epistasis (inbreeding depression).
3. Because of the heterozygous and heterogeneous nature, the populations are particularly vulnerable to change in gene and genotype structure through selection.

The best way to maintain the individual lines is through sib mating. However the quality depends on number of plants sib mated in a population. If the number of plants is lower, genetic erosion is inevitable. On the other hand, maintenance of a large population is very difficult as pollination control is difficult. Further, genetic erosion is faster if the lines are repeatedly multiplicated. Thus staggered multiplication of lines over time is advocated. At S K N College of Agriculture, Jobner the lines are multiplicated once in 3 years and the lines are maintained at ambient temperature in dark place. The germination percentage deteriorates after three years of storage, hence the multiplication is done once in three years. further, care is taken so that around 20 plants are bagged together in a line, so that sib mating in a line is effected. This strategy has been found effective in maintaining the germplasm lines in coriander.

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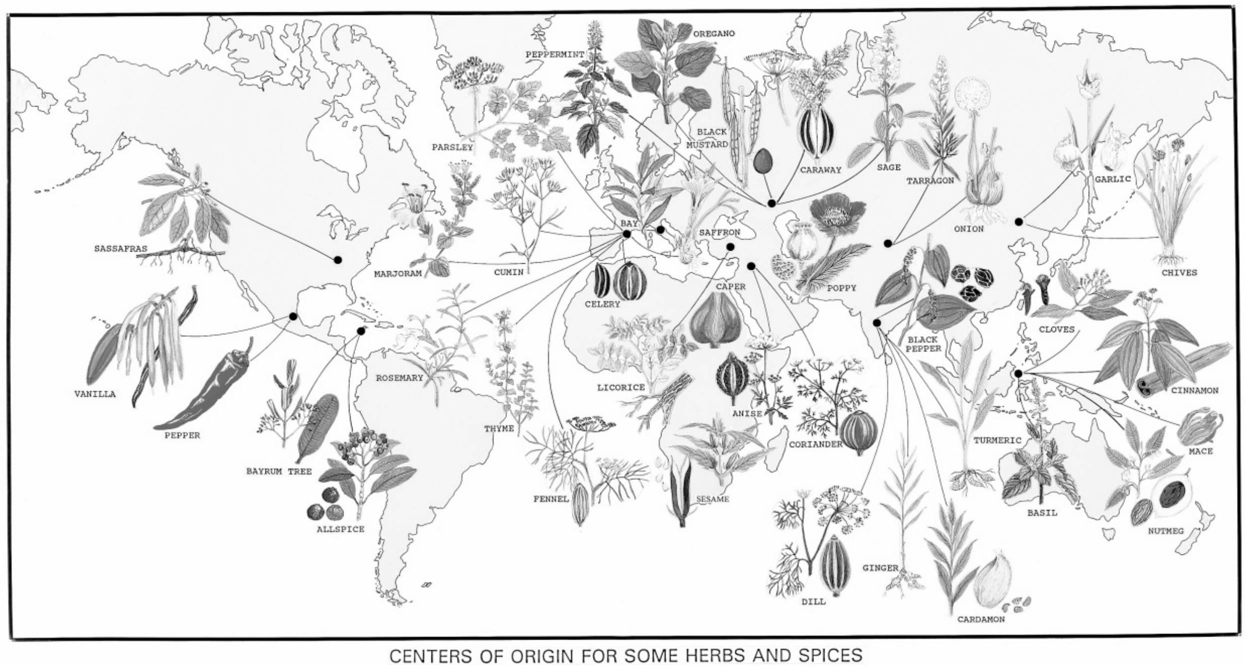

Figure 1. Centres of origin of certain spices

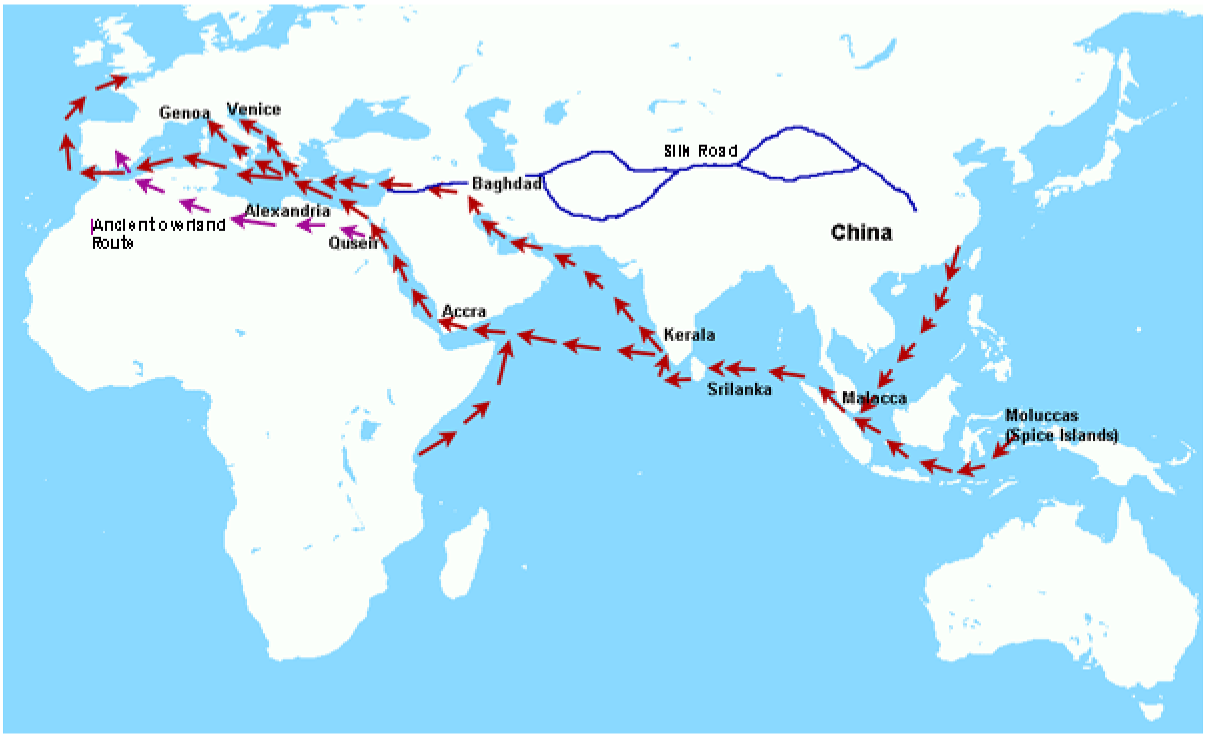

Figure 1. The old silk and spice trade routes (www.celtnet.org.uk)

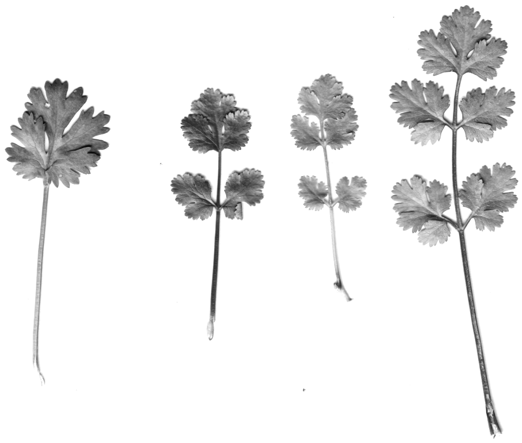

Figure 2. Classification of leaf types based on number of leaflets. Left to right- single, three and five leaflets. The difference between the third and the fourth is the length of the peduncle between the terminal and middle leaflets. The leaf types are numbered as A, B, C and D from the left.

Figure 3. Plant types in coriander. Left to right- erect, semi erect and prostrate.

Biotechnology in conservation and development of spices

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Peninsular India is a rich repository of spices and over 100 species of spices and herbs are grown in about 2 million hectares with an annual production of approximately 2.2 million tones. Black pepper, cardamom, ginger, turmeric, vanilla, capsicum, cinnamon, clove, nutmeg, garcinia, tamarind etc., constitute the major spices. Seed spices like coriander, cumin, fennel, fenugreek, dill, caraway, anise and herbal spices like saffron, lavender, thyme, oregano, celery, anise, sage and basil are equally important. Various biotechnological approaches like micropropagation, somaclonal variation, *in vitro* conservation, synseed technology, protoplast fusion, production of flavour and colouring components, and development of noval transgenics have great significance in conservation, utilization and increasing the production and productivity of spices most of which are perennial heterozygotes with many difficult to handle diseases and pests making conventional breeding time consuming and less effective. This is compounded by the lack of diversity for biotic abiotic stresses in germplasm.

The various advancements made in biotechnology of major spices are presented below.

Micropropagation

Development micropropagation technology is an important pre requisite in utilizing the potential of biotechnology in crop improvement. This helps in production of disease free and certified planting materials, exploiting somaclonal variation, anther culture, development novel genotypes through trnasgenesis, *in vitro* and cryo conservation.

Black pepper and related species

Methods for micropropagation and hardening of black pepper are available using various explants from both mature and juvenile tissues (Mathew and Rao 1984, Nazeem et. al., 2004, Nirmal Babu et. al., 1997). Phenolic and endogenous bacterial contamination severely hamper establishment of black pepper cultures. Treating the explants with fungicides prior to routine sterilization followed by frequent transfer to fresh medium, use of activated charcoal and antibiotics in the culture media was suggested in reducing phenolic interference and systematic contamination.

Micropropagated plants in the nursery were superior with respect to plant height, number of leaves, number of roots and root length. Micro propagation and large scale field evaluation of tissue cultured black pepper plants fortified with PGPR and biocontrol agents like *Trichoderma harzianum* and VAM at both nursery as well as field level, in over 100 ha, covering all the pepper growing states of India was conducted involving Kerala Agricultural University, Spices Board and Indian Institute of Spices Research. The results indicated that the tissue cultured plants are superior to conventionally propagated plants using in field establishment, growth, early production of laterals and flowering (Nazeem et. al., 2004; Peter et. al., 2006; Nirmal Babu et. al., 2011). The superiority of TC plants is attributed to the better root system of micropropagated plants compared to conventional propagules.

Protocols are also available for rapid clonal multiplication of other economically and medicinally important species of Piper like *Piper longum* and *P.chaba*, *P. betle*, endangered *P. barberi* and *P. colubrinum.* Preliminary field performance of micropropagated plantlets of these species indicated that they are on par with clonally propagated plants (Sarasan et. al., 1993, Nirmal Babu et. al., 1997, 2003).

Cardamom

In vitro methods for rapid clonal propagation of cardamom have been standardized (Nadgauda et. al., 1983, Reghunath and Gopalakrishnan, 1991). High rate of multiplication coupled with additional advantage of obtaining disease free planting material makes micropropagation an important and viable alternative to conventional propagation. Kumar et al. (1985) reported successful conversion of immature floral buds to vegetative plantlets and inflorescences form an excellent source for reducing culture contamination especially since other sources are prone to high rate of contamination. Many commercial laboratories are using micropropagation techniques for large-scale production of cardamom clonal material.

Field evaluation of tissue cultured plants of cardamom has been carried out by Spices Board and IISR and the results showed that the micropropagated plants performed on par with suckers (Lukose, 1993, Kuruvilla et. al., 2005).

Ginger

Clonal multiplication of ginger from vegetative buds has been reported by many workers (Nadgauda et. al., 1980; Nirmal Babu et. al., 1997, Balachandran et. al., 1990). In ginger diseases of ginger are often spread through infected seed rhizomes and Tissue culture technique would help in the production of pathogen-free planting material of high yielding varieties. Field evaluation tissue cultured plants indicated that micropropagated plants require at least two crop seasons to develop rhizomes of normal size that can be used as seed rhizomes for commercial cultivation. In nature, ginger fails to set fruit. However, by supplying required nutrients to young flowers and *in vitro* pollination could be effected and develop 'fruit' and subsequently plants could be recovered from the fruits (Nirmal Babu et. al., 1992; Valsala et. al., 1997).

Turmeric

Successful micropropagation of turmeric has been reported by many (Nadgauda *et al*, 1978; Nirmal babe *et al* 1997, Sumathi2007). This technique could be used for production of disease-free planting material of elite plants.

Related species of *Curcuma*

Many economically and medicinally important zingiberaceous species like *Amomum subulatum* (large cardamom), *Curcuma aromatica* (kasturi turmeric), *C. amada* (mango ginger), *Kaempferia galanga, K. rotunda, Alpinia* spp *etc.,* could be micropropagated (Barthakur and Bordoli, 1992; Chang and Criley, 1993; Thomas et. al., 1996;Vincent et. al., 1992; Ravindran et. al., 1996; Geetha et. al., 1997; Sajina et. al.,1997).

Vanilla

Micropropagation of vanilla using apical meristem was standardized for large scale multiplication of disease free and genetically stable plants (Cervera and Madrigal, 1981; Kononowicz and Janick, 1984; Philip and Nainar, 1986; Minoo 2002). Vanilla being a cross pollinated crop with many meiotic chromosomal abnormalities, will give many genetically variant types among seed progenies. *In vitro* culture of vanilla seeds resulted in development of morphological and biochemical variants. Successful plant regeneration from leaf and seed derived callus was also reported in vanilla (Nirmal Babu et. al., 1997). Embryo rescue technique was successfully employed in vanilla to produce interspecific hybrid between *V.planifolia* and *V.aphylla* (Minoo, 2002).

Tree spices

Micropropagation of clove and cinnamon from seedlings has been reported (Jagadishchandra and Rai, 1986 Mathew and Hariharan, 1990). Mature cinnamon, cassia and camphor trees could also be successfully micropropagated by shoot tip culture (Mini et al, 1997, Nirmal Babu et al 2000; Huang et al 1998). Similar reports are available in curry leaf, pomogranate and tamarind (Hazarika et. al., 1995; Bhuyan et. al., 1997, Rajendra and D'Souza, 1995; Venkateswarlu and Mukhopadhyaya, 1995; Gulati et. al., 1995; Rao et. al., 1997, Nirmal babu et. al., 1997, 2000, 2003). *In vitro* shoot initiation from explants of field grown trees of nutmeg was reported by Mallika et. al. (1997).

Seed and herbal spices

Micropropagation protocols for many seed and herbal spices were available. They include coriander, peppermint, spearmint, celery, thyme, lavender, savory, ocimum, oregano, basil, sage, fennel, parsley, dill, garlic, *Eryngium foetidum,* and sweet marjoram (Bhojwani 1980; Ahuja, 1982; Chambon et. al., 1985; Rich and Pires, 1986; Venkataraman and Ravishankar, 1986; Cellarova, 1992; Furmanowa and Ozszowska, 1992; Hunault and Du-Manoir, 1992; Panizza and Tognoni, 1992;Toth and Lacy, 1992; Patnaik and Chand, 1996; Vandemoortele et. al., 1996; Sajina et. al., 1997, Iyer and Pai, 1998, Miura et. al., 1987; Shehgal et. al., 1978; Benny et. al., 1997; Patnaik and Chand 1996). Differentiation of shoot buds and embryoids from inflorescence cultures of dill was reported by Shehgal et. al. (1978). Jakhar et. al. (2003) reported i*n vitro* flowering and seed formation in cumin. Successful micropropagation, somatic embryogenesis and regeneration were also reported in saffron. *In vitro* proliferation of saffron stigma was also reported (Ding et. al., 1981; Homes et. al., 1987; Ilahi et. al., 1987; Isa and Ogasawara, 1988; Ahuja et. al., 1994 a, b; Sushma et. al., 1995, Yang et. al., 1996).

Capsicum

Micropropagation and plant regeneration in chilly was reported using various explants (Agarwal, 1988; Christopher and Rajam, 1994; Brinzel et. al., 1996; Kato et. al., 1996). Most of the *in vitro* culture experiments in capsicum is aimed either at production of secondary metabolites in cell cultures or utilisation of culture techniques for genetic manipulation of capsicum.

Plant regeneration from callus cultures and exploitation of somaclonal variation

Efficient plant regeneration protocol is essential for genetic manipulation of any crop species and also for exploitation of somaclonal variation.

Black pepper and related species

Plants could be successfully regenerated from callus cultures of many *Piper* species. Plant regeneration was reported from shoot tip and leaf with or without intervening callus phase (Nirmal Babu et. al., 1997; 2011). Joseph et. al. (1997) reported cyclic somatic embryogenesis from zygotic embryos, while Nair (2001) and Nair and Gupta (2003, 2005) reported similar results from the integument tissues. This cyclic somatic embryogenesis from meternal tissues like integuments has tremendous potential for automated micropropagation. These systems are useful for transgenic experiments for transfer of *Phytophthora* resistance. Using Plant regeneration technology Shylaja et. al. (1994) and Nazeem et. al. (1996) reported identification of tolerant somaclones through *in vitro* selection of calli as well as somaclones using crude culture filtrate and toxic metabolite isolated from *Phytophthora capsici*. Plants were regenerated from leaf and stem explants of *Piper longum*, *P. betle*, *P. chaba, P.attenuatum* and *P. colubrinum* through both direct and indirect organogenesis (Bhat et. al., 1995, Nirmal Babu et. al., 1997, Johri et. al., 1996) reported regeneration of betel vine through somatic embryogenesis.

Cardamom

Successful regeneration of plantlets from callus cultures of cardamom was reported (Rao et. al., 1982, Nirmal Babu et. al., 1997). Technology for high frequency plant regeneration from rhizome and vegetative bud-derived callus cultures is available. This excellent regeneration system was used for developent of somaclonal variation and selection of useful katte resistant genotypes. A few Katte tolerant somaclones were identified (Nirmal babu et. al., 1997, Peter et. al., 2001).

Ginger

Regeneration of plantlets through callus phase has been reported from various explants (Kacker et. al., 1993; Nirmal Babu et. al., 1997). This system could be used for inducing somaclonal variability which is very important in crops were conventional breeding is hampered by lack of seed set. Somaclones could also be used for screening against biotic and abiotic stress. Field evaluation of somaclones indicated high variability with regard to various agronomic characters and other yield attributes. A few promising high yielding lines, with tolerance to rhizome rot were identified from the somaclones (Nirmal Babu, 1997). Kulkarni et. al., (1984) reported isolation of *Pythium*-tolerant ginger by using culture filtrate as the selecting agent.

Turmeric

Organogenesis and plantlet formation were achieved from the callus cultures of turmeric (Shetty et. al., 1982). Variants with high yield, better rhizome characters, high curcumin content were isolated from tissue cultured plantlets (Nadgauda et. al., 1982; Praveen 2005, Sumathi, 2007). Root rot disease tolerant clones of turmeric cv. Suguna were isolated using continuous in vitro selection technique against pure culture filtrate if *Pythium graminicolum* (Gayatri et. al., 2005). Successful plant regeneration and variations among regenerated plants were reported in *Kaempferia galanga* (Ajith Kumar and Seeni, 1995).

Tree spices

Protocol for regeneration of plants through somatic embryogenesis from seedling explants in *Cinnamomum verum* was standardized (Mini et. al., 1997). Somatic embryogenesis from hypocotyl callus in *C. camphora* has been reported (Jagdishchandra and Sharief, 1995).

Seed and herbal spices

Somatic embryogenesis in some species of Apiaceae has been summarized by Lourdes and Alfermann (1994). Regeneration of plants from callus cultures with reliable somaclonal variation was reported in celery, fennel, lavender, caraway, anise, parsley, poppy, oregano and sage (Choi and Soh,1997; Donovan et. al., 1994; Okamoto et. al., 1994; Hunault and Maatar, 1995, Onisei *et al*, 1994 , Ammirato,1983; Chand and Roy, 1981; Jha et. al., 1982; Erdelsky, 1990; Neena Kumari and Sarathy, 1992; Kim et. al., 1996; Sajina et. al., 1997; Shukla et. al., 1997; Sastry et. al., 1997). Variation in essential oil composition of plants regenerated from protoplasts of peppermint was reported (Okuyama et. al., 1995). Reports are also available *on in vitro* selection for salt tolerance in fenugreek, *Trigonella foenum-graeceum* (Settu et. al., 1997), *in vitro* selection for resistance to *Alternaria* blight in cumin (Shukla et. al., 1997) and drought tolerance in coriander (Stephen et. al., 1997). Lacy et. al., (1996) identified MSU - SHK 5, a somaclonally derived *Fusarium* yellows resistant line in celery.

Synthetic seeds

Artificial or 'synthetic seeds' can be an ideal system for low cost plant movement, propagation, conservation and exchange of germplasm. Synthetic seeds were developed by encapsulating *in vitro* developed small shoot buds in 3% calcium alginate in various spices like black pepper, cardamom, ginger, vanilla, turmeric, camphor, cinnamon, celery, lavender, fennel etc (Redenbaugh et. al., 1986; Pratap, 1992; Sajina et. al., 1997, Sharma et. al., 1994; Minoo, 2002; Yamuna, 2006).

Micro rhizomes

Technology for development of microrhizomes was standardized in tuberous crops like Ginger, turmeric and *Kaempheria* (Bhat et. al., 1994; Sharma and Singh, 1995; Sumathi 2007, Nirmal babu et. al., 1997, Geetha et. al., 2000). The micro- mini rhizome path way is an important method to develop disease free seed rhizomes similar to that of microtubers of potato. In addition the micro rhizomes are ideally suited for germplasm exchange, transportation and conservation

Anther culture

Since the first report of androgenesis in *Datura* anther and microspore culture has become an important source for development of haploids and dihaploids. This is especially important in perennial crops like spices to understand their genetic architecture and in exploiting hybrid vigour. Plant regeneration from anther callus was reported from diploid and tetraploid ginger and cardamom (Samsudeen, 1997; Nirmal Babu, 1997; Ravindran et. al., 2002). Callus formation followed by regeneration of adventitious embryos from microspores from anther and microspore cultures has been reported in fennel (Matsubara et. al., 1995). Regeneration of adventetious embryos was successfully induced in celery microspores by anther and microspore culture (Dohya et. al., 1997). Development of haploid capsicum through androgenesis was reported (Gonzalez et. al., 1996).

Protoplast culture and development of protoclones

Protoplast is an important tool for parasexual modification of genetic content of cells. The absence of cell wall makes the protoplast suitable for a variety of manipulations like uptake of cell organelles, microorganisms, foreign genetic material to form genetically modified cell and production of somatic hybrid cells. Successful isolation of protoplast is a prerequisite for certain genetic transformation experiments.

Successful isolation and culture of protoplasts were reported in capsicum, black pepper, *Piper colubrinum*, ginger, cardamom, and vanilla (Sim et. al., 1995; Minoo 2002, 1996; Shaji et. al., 1996). Organogenesis and plant regeneration from isolated protoplasts are available in chillies (Fari and Czako, 1981; Saxena et. al., 1981; Agarwal, 1988), fennel (Miura and Tabata, 1986), fenugreek (Sen and Gupta, 1979; Multani, 1981), peppermint (Sato et. al., 1993; Okuyama et. al., 1995), garlic (Ayabe et. al., 1995) and saffron (Isa et. al., 1990) etc. Suh Sang Ki and Park (1995) reported protoplast fusion and culture in garlic. Successful production of interspecific hybrid between peppermint and gingermint was reported by Sato et. al. (1996).

Genetic transformation

Black pepper

Reports are available on standardization of *Agrobacterium* mediated gene transfer system in *P.nigrum* (Sim et. al., 1995, Sasikumar and Veluthambi, 1996 b; Nirmal Babu et. al., 2005). Mani and Manjula (2011) reported successful development of vacuum infiltration method in *Piper colubrinum*, as a rapid transient method for expression of GUS (b-Glucuronidase) reporter gene and introduction of hairpin vector for endogenous gene silencing. This indicated that transient gene silencing could be used as a rapid, preliminary high-throughput tool for *P. colubrinum* functional genomics. Asha and Rajendran (2009) reported *in planta* transformation in black pepper via pollen tube pathway using the total exogenous DNA of *Piper colubrinum*, a wild relative species of Piper resistant to *Phytophthora capsici*. The resulting seeds germinated *in vitro* by embryo rescue. 39.2% of the putative transforments gave 'tolerant' reaction.

Cardamom, ginger and turmeric:

In a preliminary study cardamom callus was transformed using biolistics and GUS gene was successfully expressed in the bombarded callus tissue (Nirmal Babu *et. al*., 1998). Transient expression of GUS was successfully induced in ginger embryogenic callus through biolistics bombarded with plasmid vector pAHC 25 and promoter Ubi-1 (maize ubiquitin) callus tissue (Nirmal Babu et. al., 1998). Suma et. al. (2008) reported the *Agrobacterium* mediated genetic transformation of ginger buds through somatic embryogenesis, with a transformation frequency of 1.1 to 2.2 %.
Shirgurkar et. al. (2006) reported an efficient protocol for genetic transformation for turmeric through particle bombardment. PCR and histochemical GUS assay confirmed the stable transformation

Molecular characterization
Molecular characterization and diversity studies

DNA markers viz: RAPD, AFLP, ISSR, SSR, sequence data from mitochondrial, chloroplast and ribosomal DNA etc were used for molecular profiling, studying species inter relationships, varietal identification, estimating genetic purity, checking adulteration, mapping ad tagging of genes of agronomic importance.

Molecular Phylogeny and diversity of Piperaceae was elucidated for better understanding of their origins and species interrelation ships in the genus *Piper* (Gaia et. al., 2003, 2004; Lebot et. al., 1991, 1999; Jaramillo and Manos, 2001; Chaveerach et. al., 2002; Wadt et. al., 2004). Molecular profiling of black pepper cultivars and its related species were well studied for estimating the genetic diversity (Nirmal Babu et. al., 2003; Ravindran et. al., 2000; Saji 2006; Babu et. al., 2003; Anjali et. al., 2004; Ranade et. al., 2002; Pradeepkumar et. al., 2001; 2003; Nazeem et. al., 2005). Sreedevi et. al. (2005) used RAPD to characterize 7 new high yielding lines of black pepper and developed a bar code to identify the varieties.Molecular Phylogeny of Zingiberales relationships in Monocots was elucidated based on sequence data analysis of nuclear ribosomal DNA and chloroplast DNA (Chase 2004; Ngamriabsakul et. al., 2003). Kress et. al. (2002) studied the phylogeny of the gingers (Zingiberaceae) based on DNA sequences of the nuclear internal transcribed spacer (ITS) and plastid *matK* regions and proposed a new classification of the Zingiberaceae. Gao et. al. (2008) used SRAP markers to analyze phylogenetic relationship of 22 species of Chinese *Hedychium*.

Jayakumar et. al. (2005) studied about 11 species representing 5 major tribes viz., *Amomum, Aframomum, Alpinia,, Hedychium* and *Elettaria* and 96 collections of cardamom germplasm representing the range of genetic variability were studied for RAPD, PCR - RFLP and ISSR polymorphism for estimation of genetic diversity. DNA markers were used to study the diversity in ginger germplasm in ginger (Sasikumar and Zachariah 2003; Wahyuni et. al., 2003) and *Zingiber zerumbet (*Kavitha and Thomas, 2008). Jatoi et. al. (2006) tested cross amplification potential of 12 rice SSR markers microsatellite markers in 14 genotypes from 3 genera – *Zingiber, Curcuma* and *Alpinia*.Sok-Young Lee et. al. (2007) reported isolation and characterization of eight polymorphic microsatellite markers for ginger. Molecular fingerprints of 15 *Curcuma* species were developed using ISSR and RAPD markers to elucidate the genetic diversity/relatedness among the species (Syam kumar and Sasikumar, 2007).

Cao et. al. (2003) used trnK nucleotide sequencing, for identification of six medicinal *Curcuma sp.* Syamkumar (2008) studied over 36 Indian cultivars and related species of turmeric using RAPD profiling for establishing their inter-relationships. RAPD analyses showed good polymorphism among the accessions studied. Nayak et. al. (2006) carried out 4 C nuclear DNA content and RAPD analysis of seventeen promising cultivars of turmeric from India. RAPD analysis clearly showed the genetic variation among the cultivars.

Checking adulteration

Syamkumar et. al. (2005) reported standardization of protocol for the isolation of amplifiable genomic DNA from dried capsules of traded cardamom. RAPD profiling coupled with biochemical characterization was used to characterize different international brands of cardamom to determine their quality. A simple and rapid method for isolating good quality DNA from rhizomes of turmeric and ginger has been perfected (Shyam Kumar et. al. 2003). Genetic profiling of traded ginger from India and China using RAPD and ISSR primers gave consistent amplification pattern and significant variation was observed between the produces from the two countries (IISR 2008).

Jiang et. al. (2006) used metabolic profiling and phylogenetic analysis for authentication of ginger. They used these tools to investigate the diversity of plant material within the ginger species and between ginger and closely related species in the genus *Zingiber* and demonstrated that all *Zingiber officinale* samples from different geographical origins were genetically indistinguishable but the other *Zingiber* species were significantly divergent, allowing all species to be clearly distinguished using this analysis.

Detection of extraneous *Curcuma* sp. contamination of powdered samples of turmeric using random amplified polymorphic DNA was reported by Sasikumar et. al. (2004) using this method. The analysis of three market samples of turmeric powder from Kerala, India, revealed the prevalence of *C. zedoaria* (wild species) powder over the *C. longa* (turmeric) powder. The other studies on genetic purity and checking adulteration are those of Cao et. al. (2001), Sasaki et. al. (2002, 2004) who used sequence analysis of Chinese and Japanese *Curcuma* drugs on the 18S rRNA gene and trnK gene and the application of amplification refractory mutation system analysis for their authentication. Xia et. al. (2005) used molecular (5S-rRNA spacer domains) and chemical fingerprints for quality control and authentication of *Rhizoma Curcumae*, a traditional Chinese medicine . Xia et. al. (2005) used 5S rRNA spacer domain specific primers to ensure the quality of *Rhizoma Curcumae* derived from three species of *Curcuma* namely *C. phaeocaulis, C. wenyujin* and *C. kwangensis* from their common adulterants. *C. longa* and *C. chanyujin* are identified as the common adulterants used in the *Rhizoma Curcumae*

Genetic fidelity testing and somaclonal variation

DNA profiling was used to study the genetic fidelity of micropropagated, *in vitro* conserved and cryo-preserved lines in ginger (Geetha, 2002; Peter et. al., 2002, Ravindran et. al., 2004; Rout et. al., 1998). Normal Babe et. al. (2003) used RAPD profiles as an index for estimating genetic variability of selected 'variants' among micropropagated and callus regenerated plants. RAPD profiles indicated high amount of variability among the selected micropropagated and callus regenerated plants of ginger and the majority of the morphological variants selected from earlier studies did show variations in their DNA profiles.

Normal Babe et. al. (2003) studied morphological and molecular variations among micropropagated and callus regenerated plants and found variations in both but with higher percentage of variation in callus regenerated soma clones. *In vitro* plants developed through micro rhizome exhibited least amount of variations. The genetic fidelity studies of turmeric germplasm conserved in *in vitro* genebank using RAPD profiling showed their genetic integrity (Geetha, 2002, Ravindran et. al., 2004). Salvi et. al. (2001, 2002, 2003) Praveen (2005) and Sumathi (2007) analyzed turmeric somaclones using RAPD and concluded that plants regenerated using shoot tips showed uniform banding pattern, whereas, callus derived and inflorescence derived plants showed polymorphism in banding pattern when compared with conventionally propagated plants. Genetic stability of 12 month old *in vitro* conserved *C. longa* cv.

Prathibha plants were assessed using RAPD and no significant variation was observed in mother plants and *in vitro*-conserved plantlets. (Tyagi et. al., 2007).

Development of mapping population

A mapping population of 200 segregating progenies was developed between Subhakara × Panniyur-1for gene tagging and preparation of preliminary genetic map of black pepper (Nirmal Babu et. al., 2003). Preparation of frame work molecular map is in progress. Inheritance of patterns of Phytophthora resistance in this mapping population indicated that the resistance segregated in the nearest ratio of ratio of 1 resistant : 15 susceptible which is a ratio probably controlled by genes with duplicate functions.

Detection of pathogens

Kumar et. al. (2004) characterized the genetic diversity of *Ralstonia solanacearum* causing bacterial wilt of ginger using REP-PCR and PCR- RELP. Thirty –three strains of *Ralstonia solanacearum*) isolated from ginger, paprika, chilli, tomato, *Chromolena* and potato from different regions of India, were phenotyped for biovar characterization which revealed the predominance of biovar 3 in India. Molecular analysis by REP-PCR, ITS-PCR and RFLP-PCR classified the strains in to three clusters at 70% similarity, where ginger strains are grouped in Clusters I and II. Strains from potato (biovar 2) clustered in the III cluster. Kumar and Anandaraj (2006) developed an efficient DNA isolation protocol and PCR based detection of bacterial pathogen in soil. This PCR based method using universal *Ralstonia solanacearum* specific primer offer a rapid method for unambiguous detection of this pathogen at a concentration of 103-104 cells per gram of soil.

Tagging important characters

Johnson et. al. (2005) used male parent-specific RAPD markers for identification of hybrids in black pepper (*Piper nigrum* L.). Banerjee et. al. (1999) studied molecular basis of genotypic differentiation between the male and female plants of dioecious *P. longum* L. and identified two RAPD markers specific to male plants. Philip et. al. (2000) used RAPD profiles to differentiate three female varieties of *P. longum.* Manoj *et al*. (2004) studied the molecular basis of differentiation between male and female plants of *Piper longum* using RAPD. Sheji Chandran et. al. (2006) identified a RAPD marker associated with *Phytophthora* resistance and converted it in to SCAR marker. Pimchai et. al. (1999) reported association of a few isozymes markers in the identification of some of the early flowering *Curcuma* species.

Isolation of useful genes

Work on isolation of genes responsible for agronomically important characters, especially for biotic and a biotic stresses was done in spices. Different methodologies have been followed for isolation and cloning of R genes as well as PR protein genes A few putative genomic and c DNA fragments associated with resistance related genes are isolated and programmes on isolation, cloning and validation of full length genes is in progress.

Piper species

Johnson et. al. (unpublished) reported amplification, isolation and sequencing of putative beta-1, 3-glucanase gene from *Piper colubrinum* was achieved using glucanase specific primers. Targeted amplification of an R gene from mRNA population isolated from *Piper colubrinum* challenged with *Phytophthora capsici* was done using degenerate primers. A 252 bp fragment with Sequence similarity is also close to *Phytophthora* resistance gene viz., blight resistance protein RPI gene from *Solanum bulbocastanum.* Amplification and Cloning of Partial Sequence of the Chitinase Gene was also reported from *Piper.*A PCR-based suppression subtractive hybridization (SSH) was used by Ditto and Manjusha (2005) to identify *Piper colubrinum* resistance genes that are differentially expressed in response to the signaling molecule, salicylic acid (SA).

Osmotin an antifungal PR-5 gene homologue from *Piper colubrinum* has been cloned full length and work is in progress to express and purify the recombinant protein and analyse its antifungal activity. Mani and Manjula (2010) reported the cloning and sequence characterization of two isoforms of *osmotin*, an antifungal *PR-5* gene homologue, from a salicylic acid-induced subtracted cDNA library earlier generated in *P. colubrinum.* These cloned isoforms of osmotin from resistant species could be candidates for molecular breeding for the improvement of black pepper as well as candidates for the study of structure based mechanism of antifungal activity attributed to PR-5 family.

Cucumber mosaic virus (CMV) and *Piper yellow mottle virus* (PYMoV) are the important viruses infecting black pepper. Bhat *et al.* (2005) reported isolation and sequencing and cloning of CMV coat protein gene infecting black pepper. The utility of this gene in inducing virus resistance in black pepper is being studied using transgenic path way. Molecular cloning of a cDNA fragment encoding the defense related protein β-1,3-glucanase in black pepper (*P. nigrum* L.) and methyl glutaryl CoA reductase in *Piper colubrinum* was reported (Girija et. al., 2005a , b). Bioprospecting of novel genes form black pepper was attempted by Sujatha et. al. (2005). They used heterologus probes to identify the presence of pea lectin genes and tomato protease inhibitor genes in black pepper.

Zingiberaceous crops

Backiyarani et. al. (2005) reported cloning of coat protein gene of a highly variable ‘Kursuppara’ isolate of *Cardamom mosaic virus* infecting cardamom in order to develop pathogen derived resistance in cardamom. Nair and Thomas (2006) reported isolation, characterization, and expression of resistance gene candidates (RGCs) using degenerate primers based on conserved motifs from the NBS domains of plant resistance (*R*) genes from cultivated and wild *Zingiber* species. They (Nair and Thomas, 2007) also reported evaluation of resistance gene (*R*-gene) specific primer sets and characterization of resistance gene candidates in ginger.

Priya and Subramanian (2008) reported isolation and molecular analysis of R-gene in resistant ginger cultivars against *Fusarium oxysporum.* They observed that the R-gene is present only resistant cultivars. These cloned R-genes provide a new resource of molecular markers for marker assisted selection and rapid identification of *Fusarium* yellows resistant ginger cultivars. Kavitha and Thomas (2008a, b) employed AFLP markers and mRNA differential display to identify genes whose expression was altered in a soft rot-resistant accession of *Zingiber zerumbet* before and after inoculating it with *Pythium aphanidermatum*, which is a principal causative agent of soft-rot disease in ginger A few differentially expressed transcript-derived fragments (TDFs) were isolated, cloned and sequenced. Nair *et al.* (2010) identified a member of the pathogenesis-related protein group 5 (PR5) gene family in *Z. zerumbet* that is expressed constitutively but upregulated in response to infection by *P. aphanidermatum.*

In an effort to isolate resistance source to *Ralstonia* induced bacterial wilt in ginger, Prasath et. al. (2010) amplified two putative PR5 like protein genes, *Ca*PR5 and *Zo*PR5 from *Curcuma amada* and *Zingiber officinale*, which encodes precursor proteins of 227 and 224 amino acid residues, respectively, and shares high degrees of homology with a number of other PR5 genes. The results suggest that the *Ca*PR5 could play a role in the molecular defense response of *C. amada* to pathogen attack.

Chen et. al. (2005) reported isolation, cloning and characterization of a mannose-binding lectin form cDNA derived from ginger rhizomes. The full-length cDNA (746 bp) of *Z. officinale* agglutinin (*ZOA*) was cloned and this contained a 510 bp open reading frame encoding a lectin precursor of 169 amino acids with a signal peptide. *ZOA* was a mannose-binding lectin with three typical mannose-binding sites. Semi-quantitative RT-PCR analysis revealed that *ZOA* expressed in all the tested tissues of Z.

officicale including leaf, root and rhizome, suggesting it to be a constitutively expressing one. *ZOA* protein was successfully expressed in *Escherichia coli* with the molecular weight as expected.

The violaxanthin de-epoxidase (*VDE*) is the key enzyme of xanthophyll cycle and plays an important role in protecting photosynthesis apparatus from the damage of excessive light. The expression patterns of *VDE* in ginger (*GVDE*) in response to light were characterized. The results showed that VDE plays a major role in alleviating photo inhibition (Huang *et al.,* 2007).Yua et. al. (2008) reported isolation and functional characterization of a b-eudesmol synthase from *Zingiber zerumbet*. Isolation and characterization of a novel *PKS* gene from ginger was reported (Radhakrishnan and Soniya 2009; Radhakrishnan et. al. 2009).

Joshi et. al. (2010) used degenerate primers designed from conserved NBS-LRR region of known resistance genes (R-genes) to isolate resistance gene analogs from *Curcuma longa* cultivar suroma. Sequence comparisons of the 450-600 bp amplicons revealed significant sequence similarity with the amino acid sequences of known R-genes with kinase-1a, kinase-2 and hydrophobic motifs.

Curcuminoids are pharmaceutically important compounds isolated from the herb *Curcuma longa*. The curcuminoids in *C. longa* are synthesized by a collaboration of two type III PKSs, dike tide-CoA synthase (DCS) and cur cumin synthase 1 (CURS1, the first identified CURS) (Matsuyama et. al., 2009a). Two additional type III polypeptide syntheses, named CURS2 and CURS3, that are capable of curcuminoid synthesis were identified and characterized.The availability of the substrates and the expression levels of the three different enzymes capable of curcuminoid synthesis with different substrate specificities might influence the composition of curcuminoids in the turmeric and in different cultivars (Matsuyama et. al., 2009).

Others

Molecular cloning of mannose-6-phosphate reductase and its developmental expression in celery was studied by Averred et al. (1997).

***In vitro* conservation and cryo preservation of germplasm**

Most of the germplasm of tropical spices is conserved in seed genebank and clonally field repositories, where they are threatened by serious diseases. Storage of germplasm in seed banks is not practical in these spices as they are vegetative propagated and seeds are recalcitrant and heterozygous. Hence storage of germplasm *in vitro* and cryo gene banks is a safe alternative

In vitro conservation

In vitro conservation involves maintenance of explants in a sterile, pathogen-free environment and is widely used for the conservation of species that produce recalcitrant seeds, or do not produce seeds. The principle of slow growth storage is that the safety of *in vitro* culture be ensured without disadvantages of frequent subculturing. Thus the risk of contamination at each transfer interval, inputs in terms of labour and consumables are reduced. For short-and medium-term storage the aim is to increase the intervals between subcultures by reducing growth. This is achieved by modifying the environmental conditions, including the culture medium to realize slow-growth conservation. The most widely applied technique is temperature reduction (varying from 0-5^{o}C for cold tolerant species to 9-18^{o}C for tropical species) that can be combined with a decrease in light intensity or storage in the dark and adjustment of the growth medium. Though growth reduction can generally be achieved by lowering the culture temperature, but the scope for temperature reduction depends upon the species to be conserved. Several methods, such as temperature reduction, medium modification, use of osmoticums, etc., have been found to reduce the rate of growth of tissue cultures, so that it can be kept unattended for moderate length of time (Engelmann, 1997, Withers, 1980; 1987; 1991; Withers and Williams, 1986; Ashmore, 1997).

Alternatives to standard slow-growth conservation include modification of the gaseous environment of cultures, desiccation and encapsulation of explants.

Conservation of pepper, cardamom, herbal spices, vanilla and ginger germplasm in *in vitro* gene bank by slow growth was reported. (Geetha et. al., 1995; 1996; Nirmal Babu et. al., 2005, Minoo, 2002). Conservation of genetic resources in *in vitro* gene banks is now an established convention and two gene banks for conservation of spices germplasm functions at IISR and National Bureau of Plant Genetic Resources (NBPGR0)

Cryopreservation

For long-term conservation of the problem species, cryopreservation is the only effective method currently available. Liquid nitrogen (–196°C) is routinely used for cryogenic storage, since it is relatively cheap and safe, requires little maintenance and is widely available. Plant germplasm stored in liquid nitrogen (-196°C) does not undergo cellular divisions. As such, plants can be stored for very long time periods and both the problem of genetic instability and the risk of losing accessions due to contamination or human error during subculturing are overcome. Most cryopreservation endeavors deal with recalcitrant seeds, *in vitro* tissues from vegetative propagated crops, species with a particular gene combination (elite genotypes) and dedifferentiated plant cell cultures. Cryopreservation methods have been developed for black pepper, ginger, cardamom, capsicum etc and the NBPGR maintains the spices germplasm in cryo gene banks. (Nirmal Babu et. al., 2011)

Pollen storage

Pollen storage can be considerable value supplementing the germplasm conservation strategy by facilitating hybridization between plants with different time of flowering and to transport pollen across the globe for various crop improvement programmes in addition to developing haploid or homozygous lines. Cryo conservation of pollen and its utilization in inter specific hybridization in vanilla was reported by Minoo et. al. (2010). An advantage is that pests and diseases are rarely transferred by pollen (excepting some virus diseases). This allows safe movement and exchange of germplasm as pollen.

DNA storage

Concurrent with the advancements in gene cloning and transfer has been the development of technology for the removal and analysis of DNA. DNAs from the nucleus, mitochondrion and chloroplast are now routinely extracted and immobilized onto nitrocellulose sheets where the DNA can be probed with numerous cloned genes. These advances, coupled with the prospect of the loss of significant plant genetic resources throughout the world, have led to the establishment of DNA bank for the storage of genomic DNA. The conserved DNA will have numerous uses *viz*., molecular phylogenetics and systematics of extant and extinct taxa, production of previously characterized secondary compounds in transgenic cell cultures, production of transgenic plants using genes from gene families, *in vitro* expression and study of enzyme structure and function and genomic probes for research laboratories.

The advantage of storing DNA is that it is efficient and simple and overcomes many physical limitations and constraints that characterize other forms of storage (Adams 1997; Adams et. al., 1994). The disadvantage lies in problems with subsequent gene isolation, cloning and transfer but, most importantly, it does not allow the regeneration of live organisms. DNA banking is yet to catch up in spices. DNA samples of over 600 genotypes of spices are stored in the DNA bank of IISR.

Production of secondary metabolites

Biotechnology can be utilized to exploit the potential of spices for bio production of useful plant metabolites. The use of tissue culture for the biosynthesis of secondary metabolites particularly in plants of pharmaceutical significance holds an interesting alternative to control production of plant constituents. This technique is all the more relevant in recent years due to the ruthless exploitation of plants in the field leading to reduced availability.

In vitro Proliferation of stigma of saffron and *in vitro metabolite* production from saffron tissue cultures was reported (Sano and Himeno, 1987; Venkataraman et. al., 1989; Sarma et. al., 1990; Vishwanath et. al., 1990; Sarma et. al., 1991; Bhagyalakshmi et. al., 1995). Production of flavour components and secondary metabolites *in vitro* using immobilized cells is an ideal system for spices crops. Central Food Technological Research Institute, Mysore has done pioneering work in this field especially in the production of saffron and capsaicin (Ravishankar et. al., 1993; 1995; Venkataraman and Ravishankar, 1997). Johnson *et al* (1996) reported biotransformation of ferulic acid vanillamine to capsacin and vanillin in immobilized cell cultures of *Capsicum frutescens.* Reports on the *in vitro* synthesis of crocin, picrocrocin and safranel from saffron stigma (Himeno and Sano, 1995) and colour components from cells derived from pistils (Hori et. al., 1988) are available for further scaling up. Production of essential oils from cell cultures (Ernst, 1989) and accumulation of essential oils by *Agrobacterium tumefaciens* transformed shoot cultures of *Pimpinella anisum* was reported (Salem and Charlwood, 1995). Regulation of the shikimate pathway in suspension culture cells of parsley (Conn and McCue, 1994) and production of anethole from cell cultures of *Foeniculum vulgare* (Hunault et. al., 1989) was also reported. Growth and production of monoterpene by transformed shoot cultures of *Mentha citrata* and *Mentha piperata* in flasks and fermentors was reported by Hilton et. al. (1995). Chavez et. al.(1996) reported bio synthesis of sesquturpenic phytoalexin capsidol in elicited root cultures of chilli pepper. Production of rosmarinic acid in suspension cultures of *Salvia officinalis* has been discussed by Hippolyte et. al. (1992). Phenyl propanoid metabolism in suspension cultures of *Vanilla planifolia* was studied by Funk and Brodelius (1990). Reports on production of phenolic flavour compounds using cultured cells and tissues of vanilla are also available (Dorenburg and Knorr, 1996). *In vitro* production of petroselinic acid was reported from cell suspension cultures of coriander (Kim et. al. 1996a).

In vitro proliferation of mace and synthesis of flavor components in culture was reported by Normal Babe *et al*, (1992). This technique, if refined further, has tremendous potential for industrial production of mace tissue and *in vitro* production of myristicin and myristic acid.

Future perspectives

Reasonable progress has been made in developing protocols for micropropagation are available for most of the spices. These technologies are to be adopted for commercial multiplication wherever necessary. Conservation of genetic resourses in *in vitro* , cryo, pollen and DNA gene banks is another positive development. Use of molecular markers for genetic characterization of germplasm as well as plant varieties need to be given priority especially in post GATT scenario. This also helps in developing finger prints and diagnostic markers for varietal identification which is of immense use in certification process of planting materials. Production of dihaploid lines using anther and pollen culture for will increase the efficiency of conventional plant breeding. Development of high density molecular maps and gene tagging will help in MAS and reducing breeding time especially in perennials. This coupled with whole genome sequencing will provide enormous information for isolation and mining of useful genes of great commercial importance especially in spices. Application of recombinant DNA technology for production of resistant types to biotic and abiotic stress has to go a long way before they can be effectively used in spices improvement. Though programmes have been initiated in many laboratories in *in vitro* secondary metabolite production these techniques are to refined and scaled up for possible industrial production of these products. Because of their commercial potential, intensification of biotechnological activities in spices are important in the coming decade.

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Quality planting material availability in major spices – problems and prospects

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The spices production in India is in the order of 5.37 million tonnes from an estimated area of 2.94 million ha. The area and production of spices in the country showed a substantial increase during the last thirty years with average annual growth rates of 2.2 per cent and 5% respectively. Exports of spices from India increased substantially and have touched a new peak through spectacular growth in export earnings during 2010-11. The exports fetched a revenue of 1502.85 million US $ (Rs. 6840.71 crores) through an export of 5,25,750 tonnes of spices. However the productivity of all major spices is much lower than the productivity recorded in other producing countries. The major reason identified for the low productivity is the poor coverage of area under high yielding varieties and poor management practices followed. 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. In fact, the Ministry of Agriculture, Government of India has identified inadequate availability of quality planting materials being the single most important factor that contributes to low productivity of horticultural crops, including spices.

Importance of planting material in spices

Planting material, its type and quality are of paramount importance in spice cultivation. In other words, it is the single most important factor around which the entire gamut of other spice trade related activities revolves. It is of 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 will result in enormous loss in the later stages. Hence, genuineness, quality and health of planting material are the major requirements of multiplication, sale and adoption of any planting material.

Production mechanism

Considering the growing demand of the spices, planting material production programme was the major programme undertaken under the Centrally Sponsored Schemes sponsored by the Government of India. These programmes were intensified with higher financial allocation since VIII Plan under Centrally Sponsored Scheme, "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 percent 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 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.

Existing Infrastructure

Multiplication of planting material and seed 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 planting material supplied under private sector.

State government nurseries

Most of the nurseries have been established by the respective State Governments according to the type of crops being 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.

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; Indian Institute of Horticultural Research, Bangalore; Central Institute for Arid Horticulture, Bikaner; Central Institute for Sub-Tropical Horticulture, Lucknow; Central Institute for Temperate Horticulture, Srinagar etc.

State Agricultural Universities (SAUs)

Almost all the universities have their own nurseries 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 in certain crops or recently released varieties.

Private nurseries

It was estimated during the inception of National Horticulture Mission (NHM) that there are over 4600 registered nurseries in the country.

Hi-tech Nurseries

Most of the Hi-tech nurseries have been established in the private domain. However, under public sector only few such facilities exist.

Table 1. Available nurseries in public and private domain for various horticulture crops in the country during the inception of NHM

S. 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.	Orissa	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**

Constraints in planting material production
Operational

- Lack of awareness, inadequate facilities and lack of proper maintenance of the stock plants and nursery activities.
- Procurement of planting materials by Government Departments through public quotation leading to cheap but to poor quality materials.
- No restrictions in movement of seed material from one State to Other exist.
- Proper mechanism for storage of surplus seeds is not available.

Technical

- Inadequate and slow supply of mother plants of improved varieties from different research institutions causing delay in spread of these varieties at the desired rate.
- Non-maintenance of healthy stock or blocks of elite varieties at different centres.
- Careless multiplication of breeders seed by State Agencies
- Techniques like soil solarization and fumigation not followed by many nurseries leading to avoidable casualties in nurseries.
- Improved tools for different nursery operations not available.
- Non-availability of standardized tying and packaging material for propagation.
- Use of plastics is not very common.
- No provision for disease and pest management in commercial nurseries.
- Non existence of virus-indexing or norms in vulnerable crops like pepper etc. leading to spread of such pathogens to newer regions.
- Quarantine norms not in operation in movement of plant materials within the country causing spread of new disease strains like in pepper, ginger etc.
- No mechanism to regulate the quality of planting material being supplied to farmers through private/Govt. nurseries.

Technology available for production of disease-free planting materials in spice crops

The two most important issues in planting material production are:

1. Making available improved varieties of spices released by Research Stations in sufficient extent
2. Making available quality disease-free planting materials at the farmer's level.

Production of healthy (disease-free) planting material of spices 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.

The following are the major soil borne diseases of spice crops:

Black Pepper :
Phytophthora capsici - Foot rot /root rot
Radopholus similis
Meloidogyne incognita } Slow decline

Cucumber mosaic virus (CMV)
Pepper Yellow Mottle Mosaic virus (PYMV) } Viral disease

Cardamom :
P. meadii- Capsule rot
Fusarium oxysporum - root rot
Meloidogyne incognita
P. Vexans
Rhizoctonia Solani } *Damping off / clump rot*
Katte
Kokke kandu } virus diseases

Ginger :
Pythium aphanidermatum / P.*myriotylum* - soft rot
Ralstonia solanacearum - bacterial wilt
Fusarium oxysporum sp. *zingiberi* - yellows
Pratylenchus coffeae
Meloidogyne incognita } Nematodes

Turmeric :
Pythium graminicolum / P. *aphanidermatum*
Fusarium solani
Pratylenchus coffeae

Vanilla *Fusarium oxysporum*, *Phythophthora meadii*

Cumin *Fusarium oxysporum* sp.cumini - wilt

Coriander *Fusarium oxysporum* sp. corrianderi – wilt

Fenugreek *Rhizoctonia solani* -rootrot

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 prerequisite for the developmental agencies to further multiply the nucleus planting material provided by the R & D institution (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.

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 solizaration technique developed by Isralies is important and practicable. The nursery mixture solarized becomes an effective medium to reduce the chances of soil borne pathogens and consequent infections.

Incorporation of bio-control inoculums into the nursery mixture

Soil solarisation combined with microbial innoculum which were found as effective disease suppressers is a proposition to reduce root infections in the nursery programmes. Of the microbials available vesicular arbuscular mycorrhiza (VAM), antogonist like *Trichoderma* spp., *Psuedomonas* spp., Bacillus spp. have been extensively used for the nursery programmes as well as field management of the disease. *Glomus flasiculatum* is one VAM fungus which has been extensively investigated and was found effective in protecting the root system against *Phythophthora* capsici *Radopholus similis* and *Meloidogyne incognita*. Incorporation of VAM innoculum into the nursery mixture (either solarized or non solarised) prior to planting would ensure greater protection of the root system, leading to production of disease free planting material.

Fungal antagonists / hyperparasites

Fungal antagonists like *Tricoderma hazarianum* and *T. 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 innoculants into the nursery mixture.

Similarly, *Psuedomonas flouresens*, *Bacillus subtilis* and plant growth promoting rhizobacteria (PGPR) are the other important bacterial antogonists 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.

Seed disinfection

In the case of ginger and turmeric, the soil borne plant pathogens viz., *Ralstonia solanacearum*, *Pythium aphanidermatium*, *Pratylenchus coffeae* that remain 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 disease 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 innoculants (bio control agents). In Sikkim, seed treatment of ginger seed rhizomes at 51^0 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 bio control 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 such studies are warranted to eliminate inoculum in symptomless stems.

Virus diagnostics

CMV and PYMV 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.

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 and aromatics 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 badna), 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 limitation of this method. However, this approach becomes imperative if production of healthy planting material becomes impractical through conventional methods.

Planting material production under National Horticulture Mission

With the launch of National Horticulture Mission (NHM) during 2005-06, the availability of 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 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.

To generate awareness and ensure preparedness for production and supply of quality planting material on launching of NHM, a meeting on National Consultation on Production and Certifications of Sexually and Asexually Propagated Horticultural Crops was held at New Delhi on 23rd April, 2006. During this meeting the quality standards of the planting material covering all horticultural crops including spices prepared by ICAR were approved by the Technical Committee of Department of Agriculture and Cooperation for adoption under NHM. Simultaneously, to review the status of planting materials in the States covered under NHM, a core group was constituted under the Chairmanship of Horticulture Commissioner, Government of India. The meeting in order to augment and streamline the production of planting materials in the country recommended action on issues related to production, certification, distribution and policy matters.

The Core Group visited various states to assess the status of planting material production in private and public nurseries, source of procurement and certification mechanism adopted for production of quality planting materials. Based on the observations on the core group, the workshop on planting material rejuvenation of horticultural crops at New Delhi under the Chairmanship of Secretary (Agriculture), Government of India came out with the following recommendations for compliance by the states.

1. New techniques of propagation with higher survival rate need to be encouraged in all the nurseries.
2. Financial assistance for planting material should be given, in a phased manner, on the basis of survival rate.
3. There is a need to evolve proper standards for transportation of planting material, to reduce morality during transit. A suitable cool chain need to be evolved to prevent loss during transit. Besides, proper packing, hand ling, storage and transit facilities also need to be developed.
4. There is a need to develop crop specific progeny blocks in the State Agricultural Universities and ICAR institutes. It should be made mandatory that the private- nurseries should be provided scion material from the SAUs and ICAR Institutes.
5. Model nurseries need to be established by SAU's with funding under NHM, in order to make them the source of nucleus planting material and also the source of identified quality planting material, on a large scale.
6. A small proportion of the exotic varieties imported into the country need to be deposited by the importers at crop specific research institutes for developing a gene bank for enrichment of germplasm.
7. To assess the status of the plan ting material, there is need for regular interface between the State Agricultural Universities and the State Horticulture Departments.
8. The development agencies should plan well in advance the requirement of planting material for a particular period and accordingly place indents with the source organizations like the State Agricultural Universities, Research Institutions, Public and Private Sector nurseries.
9. Phenotype of true to type planting material need to be identified for different crops.
10. There is a need to develop crop specific standards starting from selection of poly bag, up to the stage of propagation. The standards should be applicable throughout the country. .
11. A mechanism need to be evolved and made mandatory for procuring planting material only from identified sources to avail financial assistance from the Government Department.
12. The Nursery associations need to be involved in the certification process and also procurement of planting material, for new varieties.
13. The information on requirement and movement of planting material need to be exchanged between the indenting agencies and the Horticulture Departments of the State from where the material is sourced.
14. Inter State movement of planting material need to be regulated through the State mechanism to ensure traceability of source of origin.
15. Tissue culture units already established need to be exploited to the full potential.
16. There is a need to identify central level organization to provide certification on par with ISO 9000, ISO 14000 etc. for the production of quality planting material.

17. A Model Nursery Act need to be evolved for adoption throughout the country for which, a consultant could be appointed on standard terms and conditions for preparing a draft covering both aspects of marketing as well as horticulture.
18. Provision need to be made in the Seeds Act for the enforcement of quality regulations and to make provision for penalty and prosecution.
19. Progressive farmers need to be encouraged to produce planting material under strict supervision, so as to procure the planting material from them and re-distribute among farming community.
20. Small and marginal farmers need to be encouraged to establish nurseries with financial support from the centre. A network of such nurseries should be evolved as satellite nurseries which can be linked to main /major nurseries for ensuring continuous supply of planting material.
21. Farmers participatory demonstrations need to be conducted to demonstrate the benefits of quality planting material.
22. Since the main mandate of the KVKs is to disseminate the production technologies to the farming community, these KVKs need to be strengthened to promote new varieties developed.
23. A Web portal need to be developed in order to link all certified nurseries in the country and also to apprise about the variety wise availability of planting material to ensure uniform supply in the country.
24. A system has to be put in place for accreditation of nurseries by the committee comprising of Officers from the State Government, ICAR and SAU's.
25. Once the State Governments register nurseries for procuring certified quality planting materials, it should be given wide publicity in media through its various channels viz. Television, News paper (local & National daily) etc. so that growers/farmers could be aware of the authenticity of quality planting material, they have purchased.

Periodical National level reviews are now underway to take note of the development in different states in this sector.

Schemes under NHM for planting material generation

The NHM focusses on increasing both production and productivity through adoption of improved technologies for ensuring quality, including genetic up gradation of all horticultural crops including spices. Special emphasis is given on adoption of area based cluster approach for developing regionally differentiated crops, which are most suitable for the state/region. Availability of good quality planting material being central to the development of horticulture, receives focused attention and efforts are being made to create necessary infrastructure in the form of nurseries and upgrade existing tissue culture units. This is being supplemented with plantation development programmes through addition of new areas under improved varieties to meet market demand.

Nurseries

Production and distribution of good quality, disease free seeds and planting materials is an important component of the National Horticulture Mission. Most of the States are having a network of nurseries for producing planting material, which were established through Central or State assistance. To meet the requirement of planting material for bringing additional areas under improved varieties of spices and for rejuvenation programme for old/senile plantations, assistance is provided for setting up new nurseries under the Public as well as Private sector. Infrastructure for model nurseries would include the following:

- Proper fencing
- Mother stock block maintenance under polycover to protect from adverse weather conditions
- Raising root stock seedlings under net house conditions

- Propagation house, tropical polyhouse with ventilation having insect proof netting in the sides and fogging and sprinkler irrigation systems.
- Hardening/maintenance in insect proof net with light screening properties and sprinkler irrigation systems.
- Pump house to provide sufficient irrigation to the plants water storage tank to meet at least two days requirement.
- Soil sterilization -steam sterilization system with boilers.

It has been estimated that a nursery having an area of one ha with the above mentioned facilities would cost Rs 6.25 lakhs. Assistance will be available for setting up a nursery having a minimum area of 1 ha and a maximum area of 4 ha with a total cost of Rs 25 lakhs. The nurseries established under Public sector will be eligible for 100% assistance and for nurseries in Private Sector, assistance will be 50% of the cost, as credit linked back ended subsidy. Nursery of size one ha will be classified as small nursery and beyond that will be classified as large nursery. Cost norms of nursery will be @ of Rs 6.25 lakhs per ha. Each nursery will be required to produce a minimum number of 50,000 planting materials per hectare per year.

It will be the responsibility of the nurseries to ensure quality of the planting material. In order to ensure supply of good quality planting material, nurseries should be got accredited. Nurseries will also be regulated under legislation in forcerelating to seeds and planting material. Efforts should be to establish nurseries at production cluster itself. Type of nursery proposed to be established should be clearly indicated in the Action Plan. The Plan should also contain an assessment of existing nurseries, crop wise number of planting material being produced and the additional requirement of nurseries.

Planting material for NHM will be procured from accredited nurseries. Only when adequate plant ing material is not available with accredited nurseries should it be procured from other sources after fully satisfying that planting material conforms to requisite quality parameters. SHM will, however, ensure that all nurseries set up under NHM will be accredited within period of one year through designated agencies like National Horticulture Board, State Agricultural Universities, ICAR institutes etc.

Rehabilitation of existing tissue culture units

A large number of TC units already exist, some of which need strengthening/rehabilitation. Assistance would be provided for rehabilitation/ strengthening of existing TC Units subject to a maximum of Rs 15.00 lakhs for the TC Units in the Public sector and 50% of the cost as credit linked back ended subsidy.

Setting up of new tissue culture units

New Tissue Culture (TC) units will be set up at an estimated cost of Rs. 100 lakh per unit under t he Mission. Each TC unit will produce a minimum of 15 lakh palnts of the mandated crops for which protocols are available for commercial use.

NeTC unit projects will be sanctioned to only those public sector agencies, which have required technical manpower. No recurring expenditure for the manpower and contingencies will be borne under NHM. Each TC unit will be accredited as per standards and norms of Department of Bio Technology.

100% of total cost to public sector and in case of private sector, credit linked back ended subsidy @ 50% of cost. Each TC unit will produce a minimum of 15 lakh plants of mandated crops for which protocols are available for commercial use.

Seed infrastructure

To facilitate proper handling, storage and packaging of seeds, assistance will be provided for crea ting infrastructure like drying platforms, storage bins, packaging unit and related equipments. 100% assist ance will be provided to public sector subject to a maximum of Rs. 200 lakh and assistance to private sec tor will be credit linked back ended subsidy @ 50% of cost, limited to Rs. 100 lakh per beneficiary.

Import of planting material

With a view to procure best quality planting material of latest varieties of horticultural crops, new component of providing assistance for meeting cost of planting material imported from abroad has been i ntroduced. For this, assistance will be provided @ 100% of cost to State Government/ PSUs, subject to a maximum of Rs. 10 lakh per beneficiary. Registered Grower Associations will be eligible for assistance @ 50% of cost, subject to a maximum of Rs. 5 lakh per beneficiary. The State Horticulture Mission will e nsure timely availability of good quality seeds and planting material to farmers at reasonable price.

Table 2. Physical target and achievement of nurseries under National Horticulture Mission

State	Target (Nos)	Achievement (Nos)
Andhra Pradesh	72	38
Bihar	186	656
Chhattisgarh	146	16
Delhi	6	
Goa	4	16
Gujarat	498	75
Haryana	306	282
Jharkhand	1021	663
Karnataka	371	339
Kerala	304	364
Lakshadweep	12	
Madhya Pradesh	487	1934
Maharashtra	1402	1872
Orissa	1078	5750
Punjab	259	252
Rajasthan	191	241
Tamil Nadu	84	276
Uttar Pradesh	1434	1039
West Bengal	364	549
Andaman & Nicobar	2	
Total	**82280**	**14363**

Source: National Horticulture Mission (www.nhm.nic.in, accessed on 25-11-2011)

Production and distribution of nucleus planting materials

Under NHM 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 spices 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, building up the required facilities in the Research Farms attached to the State Agricultural Universities, ICAR Institutes etc. The Directorate assesses the requirement of nucleus planting materials well in advance, for the large scale multiplication programme for various State Horticulture Mission Programmes and ensures their timely supply and monitor the overall production process as contemplated in the NHM. All the selected spices crops under NHM programmes assigned to the State Governments are included.

Dos AND Don’ts with regard to planting material production
Dos

- A variety wise assessment of requirement and availability of planting material should be made to justi fy setting up of new nurseries/TC units.
- All nurseries should have mother blocks.
- All nurseries/TC units should produce the minimum required quantity of the mandated crops.
- The planting material should be made available to the farmers at a reasonable price.
- Planting material as far as possible should be supplied to the farmers only through accredited nurseries.
- Nurseries set-up with Mission funds should be got accredited within a period of one year.

Don’ts

- Planting material of seedling origin should not be used for perennial fruit crops.
- Long distance transportation of planting material should be avoided.
- Quality of planting material should not be compromised on any account.

Conclusions

National Horticulture Mission aims 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 centre stage of all developmental activities. Since inception of NHM, around 14363 nurseries under public / private sector have been set up across the country by utilizing the funds available under National Horticulture Mission. The Directorate of Arecanut and Spices Development has been supplementing these efforts by implementing programmes on nucleus planting materials through various State Agricultural Universities 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. The opportunities provided by the Government of India should be aptly supported / utilized by the respective States and the Stakeholders to pave the way for the development of Spice Industry in the country in a sustainable way.

Quality planting materials availability in seed spices – Problems and prospects

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"Subijam Sukshestra Jayate, Sampadayte" is an ancient saying which sums up the importance of quality seeds. It means that a good quality seed sown in a good field gives optimum crop yield. Thus, the seed, a basic unit in agriculture plays a crucial role in boosting up the productivity and economy of the country. Without the use of good quality seed, the investments incurred on fertilizers, pesticides and water will not pay dividend which ought to be realized.

Among spices, seed spices comprise the single largest group with over 20 items coming under it. The important amongst this group are coriander, cumin, fennel, fenugreek, celery, ajowan, nigella, dill, anise etc. The area of cultivation of seed spices in India is 9,22,274 ha and the production is 5,94,120 metric tonnes. India is the largest producer, consumer and exporter of seed spices. This group has a prominent place in our national economy because of its large domestic consumption and growing demand for export. India had earned Rs. 5440 millions by exporting 52,550 tonnes seed spices to various countries (Anonymous, 2009). Being annual crops these are grown extensively in rotation with food crops and also as inter/mixed crops under rainfed/irrigated conditions.

Some of the seed spices are grown in those areas where other crop cannot be taken. Thus these are lifeline for those farmers. In India Gujarat and Rajasthan are major seed spices producing states. For coriander, fenugreek and ajowain, Rajasthan contributes 65%, 85% and 73% of total production of India, respectively. For cumin, fennel and dill Gujarat contributes maximum to the tune of 63%, 90% and 60% of total production of India, respectively. Besides Rajasthan and Gujarat other seed spices producing states are detailed in Table 1.

Table 1. Distribution of seed spices in India

Crop	Distribution in India
Cumin	Gujarat, Rajasthan, U.P.
Coriander	Rajasthan, M.P., A.P., Tamil nadu, Gujarat, Karnataka, U.P., Orissa
Fennel	Gujarat, Rajasthan, M.P., Haryana, U.P.
Fenugreek	Rajasthan, M.P., Maharashtra, Haryana, U.P., Gujarat,
Ajwain	Rajasthan, Gujarat and Andhra Pradesh
Nigella	Bihar, Jharkhand, Rajasthan and Gujarat
Dill	Rajasthan, Gujarat, J & K, U.P., Orissa, M.P., Punjab

Source: Directorate of Arecanut and Spices Development, Calicut, Kerala

There has been considerable coverage of area under seed spices but it's share towards production is less. Out of the total 63 spices grown in India, 20 are classified as seed spices with 36 per cent share in area and 17 per cent share in production of total spices in India. It is due to low productivity levels obtained by the growers. One of the main reason contributing to low productivity is non-availability of quality seed of released varieties. So far 61 varieties of 9 different seed spices crops have been released, but sufficient quantity of quality seed has not reached the farmers. The seed requirement for these crops is estimated in table 2.

Table 2. Seed requirement of seed spices present and projected after five years

Crop	All India Projections		
	Area (ha)	Seed rate (kg/ha)	Total Seed requirement (t)
Cumin (OP)	429000	12.0	5248.0
Coriander (OP)	397510	10.0	3975.1
Fennel (OP)	48530	10.0	485.3
Fenugreek (Pureline)	55170	20.0	1103.4
Ajwain (OP)	16490	3.0	49.47
Dill (OP)	6000	3.0	18

Rajasthan Agricultural University, Gujarat Agriculture University, National Research Centre on Seed Spices and some other SAUs are producing breeder seed and also TFL seed of released varieties of seed spices. The breeder seed is sold to State seed corporations for further multiplication and production of certified seed. TFL seed so produced is sold directly to the farmers. But, there is no record available which shows that how much seed produced and distributed to the farmers is of quality seed of seed spices. The seed replacement rate (SRR) is less than 10 in all the seed spice crops. This is mainly due to

1. Non availability of quality seed at the time of sowing.
2. Many times farmers are not interested in purchasing new seed
3. Crops are least cared as farmers are not treating these crops as main crop like wheat, gram, mustard.
4. Crops are grown in less acreage therefore private companies are less interested
5. Seed spices crops production is risky as much infected by diseases and pests, frost etc.
6. Non-availability of hybrid varieties
7. Non-availability of wonder varieties having disease and pest tolerance
8. Seed spices crops are severely infected by stored pets thus need proper care after harvest
9. Lack of awareness of farmers
10. Mostly farmers are growing in very small area specially for own consumption

Prospects

Production of seeds of seed spices have very bright future as requirement is increasing day by day due to increase in awareness of seed spices growers of the necessity of using quality seed. Also, the area under these crops is poised to increase in the near future. Development of new varieties will also help in increasing the demand of seed. According to increase in area in next five year the estimated demand of seeds of seed spices is given in Table 3.

Table 3. Estimated demand of seed spices in next five years

Crop	All India projections		
	Total projected area after 5 years (ha)	Total projected seed requirement after 5 years (t)	Total gross value of seed after 5 years (Rs. in Lakh)
Cumin (OP)	643500	7872.00	19680.00
Coriander (OP)	596265	5962.65	11925.30
Fennel (OP)	72795	727.95	1455.90
Fenugreek (Pureline)	82755	1655.10	1655.10
Ajwain (OP)	24735	74.21	185.51
Dill (OP)	9000	27.00	27.00

The main reason of less SRR in seed spices is less availability of seeds of cumin, coriander, fennel and fenugreek. This less availability is mainly due to

1. Less improved varieties under seed chain
2. Improper seed chain specially for seed spices
3. Less attention by the state seed corporations, national seed corporation, private seed producers, etc.
4. Problems in production of quality seed of seed spices as
    - Certification is problematic due to non-availability of DUS guidelines
    - Mostly pollinated through insects therefore isolation distance requirement is high
    - Highly infected by diseases and pests
    - Grown in arid and semi-arid areas with small holding therefore monitoring is highly cumbersome
    - Less remunerative due to less productivity

Strategy to improve SRR:

Some initiatives have been taken by Directorate of arecanut and spices development under NHM to improve the availability quality seed of seed spices. Following stretagies can used to increase the SRR of seed spices.

- To incentivize public & private sector to develop appropriate varieties for each agro-climatic zone with focus on suitable varieties for dry land farming.
- To calculate crop wise / variety wise requirement of breeder seeds to ensure seed availability so as to achieve the goal.
- To ensure multiplication of breeder seed in to foundation seed and foundation seed in to certified seed through public & private sector seed agencies.
- To ensure actual physical distribution of seeds at affordable price.
- To evolve suitable mechanism for timely certification, quality control parameters and penal action against defaulters.

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Quality planting materials availability in tree spices – Problems and prospects

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Various spices have been used by mankind to flavor food, for religious and medicinal purposes and as perfumes or even as currency since time immemorial. According to ISO there are 109 spices grown out of which 52 are cultivated in India and are recognized by Spices Board. About 17 tree spices are grown in India as given in table No. 1.

Table 1. Tree spices grown in India

SlNO	Botanical name	Family	Common name	Parts used
1	*Artocarpus lakoocha*	Moraceae	AdhtaoMonkey jack	Immature fruit[dried]
2	*Averrhoea bilimbi*	Averrhoaceae	Bilimbi, cucumber tree	Fresh fruit
3	*Averrhoea carambola*	Averrhoaceae	Carambola, caramba	Fresh fruit (sour type)
4	*Cinnamomum zeylanicum*	Lauraceae	Dalcheeni, Sreelankan cinnamon, Indian Cinnamon	Bark, Leaf
5	*Cinnamomum tamala*	Lauraceae	Tejpat , Indian cassia	Leaf, bark
6	*Cinnamomum aromaticum*	Lauraceae	Chinees cassia	Leaf, bark, immature dry fruit
7	*Garcinia indica*	Clusiaceae	Kokum, binda	Fruit rind, juice, seed.
8	*Garcinia gummigutta*	Clusiaceae	Malabar tamarind,camboj	Fruit rind
9	*Garcinia lancaefolia*	Clusiaceae	Borthekera	Fruit rind
10	*Mangifera indica*	Anarcardiacae	Mango	Immature fruit
11	*Myristica fragrans*	Myristicaceae	Nutmeg	Seed, Aril
12	*Murraya koeniji*	Rutaceae	Curry leaf	Leaves
13	*Pimenta dioica*	Myrtaceae	Allspice, Pimento, jamica pepper	Unripe fruit, (dried), leaf.
14	*Punica granatum*	Punicaceae	Anardhana, pomegranate.	Seed with aril
15	*Syzygium aromaticum*	Myrtaceae	Clove	Flower bud
16	*Tamarindus indica*	caesalpiniaceae	Tammerind	Fruit
17	*Zanthoxylum rhetsa*	Rutaceae	Mullilam, thaiphal	Fruit

Among these tree spices, Allspice and cassia are grown only in limited scale mostly in research stations where as Thaiphal and Adtao are grown mostly as wild trees in the Konkan belt and used for flavoring curries. Though mango, bilimbi, carrambola and pomegranate are used as spices they are generally classified under fruits. Among the garcinias, borthekara is grown in the north east and Malabar tamarind in Kerala and coorg district of Karnataka while Kokum is popular in Konkan area and is ideal for the Deccan. Since we are concerned with development of spices in the Deccan some of the tree spices are not suitable for the region due to the semie arid climate and extremes of temperature variations. The tree spices suitable for the region are tamarind, kokum, cinnamon, nutmeg and curry leaf though All spice and clove also may be grown with adequate protection. Improved varieties, problems in propagation and prospects are discussed in this paper.

Tamarind (*Tamarindus indica* L)

A native of tropical Africa, tamarind is well suited to the semi arid region of the Deccan and is well distributed through out India. It is generally raised on road sides, back yards, bunds, or in waste lands using seedlings and has great potential as an agro forestry species. It is commercially important being used in cuisine, medicine, paper sizing, colour printing of textiles, tanning of leather, dressing of home made baskets and as glue for wood; seed oil is industrially used and kernel powder is used in rubber manufacture. Wood is also highly valued. The area under the crop is not known but a rough estimate of production is over 3 lack tones (Hanamashetti and Kumar, 2000)

Improved varieties

Tamarind exhibits huge variations for all economically important traits (Gunasena and Hughes, 2000). Improved verieties have been selected with sour and sweet types in Thailand and Phillippines and in India sour verieties such as Prathisthan and Yogeswari red(Maharashtra), PKM- 1 and Murigam (Tamilnadu) and DTS -1 and 2 (Karnataka) as reported by Hanumashetti and Kumar (2000). There is good scope for introducing the sweet types to India and popularizing it.

Propagation

Tamarind does not breed true to type since it is a cross pollinated crop. Prolonged juvenile phase, poor quality and yield due to heterozygous population are major problems in tamarind necessitating vegetative propagation (Karale et al. 1997).

Seed propagation

Propagation through seeds may necessary in agro forestry or as rootstock. Seeds are to be collected from high yielding trees in summer. The flesh is removed manually, washed and dried in shade and stored in cool, ventilated place in suitable containers. Seeds remain viable for at least for six months in dry condition at ambient temperature mixed with sand and stored in air tight containers and seed viability can be enhanced for one year or more. Fresh seeds germinate within 5 to 1O days of sowing.

Generally no pretreatment is found necessary for germination. The best medium for germination is sand or soil mixed with cow dung. Chattopadhyay and Mohanta (1988) reported that cow dung alone or cow dung and in the medium encourage germination. A nursery potting mixture consisting of 3 parts soil,1 part compost and 1 part sand can be successfully used as a germinating medium especially in deep polyethylene bags since the seedlings produce long tap root in early stages(Troup,1921). Scarification of seeds was found to have no advantage though soaking in water or cow urine or cow dung solution increased germination (Hanamashetti and Kumar, 2008). Seedlings reach plantable size in three to four months.

Vegetative propagation

Vegetative propagation is necessary for raising plantations of improved high yielding or sweet varieties due to the heterozygous nature of seed progenies. Proven methods of vegetative propagation include rooting of cuttings, air layering, patch budding and grafting. Although rooting of cuttings was reported to be unsuccessful (Mascarenhas et al.1987), successful rooting of soft wood cuttings with 1000

PPM IBA is reported by Swaminath et al. (1990) and Srivasuki et al. (1990) and soft wood cuttings were better than semi hard wood or hard wood cuttings.

Air layering has been accomplished in tamarind (Hanamashetti and Kumar, 2008). Rooting of branches of pencil thickness two to three years old is reported; wet saw dust was found as the best etiolation medium; age of the plant influenced the rooting while early rainy season proved to be the best time for layering. Positive influence of hormones such as IBA is also reported along with genotypic difference in rooting and survival of layers.

Research work on grafting of tamarind has been compiled and reviewed by Hanamashetti and Kumar (2008). Veneer grafting has been reported to give 50% success on six month old seedlings with defoliated scions in 1978. Approach grafting is considered as a reliable method with 95% success. In this method two year old root stocks are used; union takes place within 90-120 days; Jun May and November have been found best time for success and establishment of the grafts in field was good. Further research has shown that soft wood grafting or green wood cleft grafting is more convenient and successful. Seedlings aged between six to nine months are ideal for this due to the presence of higher proportion of reducing sugars at this age. Genotype effect on soft wood grafting has also been observed. Scions have to be preconditioned for thirty days before grafting. The best time is March April when leaves fall and new growth initiates. The ideal rootstock height is 22-32 Cm and diameter is 0.3-.04 Cm and 80% recovery is obtained. This method is now adopted for large scale multiplication since shoots can be brought to the nursery and grafted. Patch budding and modified ring budding with 96% and 94% success respectively have been reported and may be adopted for *insitu* conversion of seedlings with superior selections.

Micro propagation has been attempted, successful plantlets were raised and tested but none has attained the status of commercial utilization. A dwarfing root stock is also reported from Thailand. Inter generic grafting for dwarfing on other leguminous trees has not been successful so far.

The garcinias

Kokum (*Garcinia indica* Choisy)
Malabar Tamarind (*Garcinia gummi-gutta* (L.) Robs.

The garcinias have been traditionally important to man as spice, medicine, fruit, gamboges, cooling syrup, cooking butter, source of colour and polishing agent for metals such as gold and silver. Recently these group of plants received intensive attention due to the presence of hydroxy citric acid inhibiting lipogenesis in man linked to control of obesity. Two species commercially significant are(1) kokum and (2) Malabar tamarind (Camboge). Kokum is popular and cultivated in the Konkan coast and adapted to dry climate and is valued for its juice as cooling syrup, source of natural colour, rind as spice and seed as source of butter. This species is well suited to the semi arid climate of the Deccan and has immense commercial potential. The Malabar tamarind is popular only in Coorg and Kerala used in meat and fish cuisine of local importance. Nevertheless, it is sought after as a source of hydroxy citric acid and for polishing metals.

Improved varieties

Till recently, seedlings only were planted as scattered trees in plantations or households since no varieties were known and vegetative propagation was not developed. Being dioecious and highly cross pollinated a lot of variability is reported in both species. The sex forms consist of male, female, and bisexual types. In kokum only female trees give fruit and male trees are needed for pollination and bisexual trees are few and do not yield well. So in new areas of introduction male trees have to be planted for fruiting. Kokum types with red, dark purple, yellow and white fruits are reported (Mathew *et al*. 2008) but the red coloured types are commercially important. High yield, early ripening, intense red colour, thick rind and more fat in seed are considerations in a good variety of kokum**.** Konkan Amrutha is such a variety released by Dr. Balasaheb Sawant, Konkan Krishi Vidhyapeed, Dapoli, Maharashtra and its grafts are popular in the Konkan coast.

In Malabar tamarind, male and bisexual types are seen and fruits are obtained from the latter. No variety has been released in this species though a lot of variability is reported (Muthulakshmi *et.al.* 2000). It is recommended to use types with steady annual yields of fruits weighing 200- 275 g having high levels of acid and low tannin through grafting. Two promising selections have been made at NBPGR, Trichur, Kerala with big fruit and thick rind (Abraham *et. al*. 2006).

Propagation

Propagation of kokum and Malabar tamarind can be done through seeds and vegetative means such as grafting. Practically very little research has been done in tissue culture propagation in these trees. The literature on research on this aspect on these two species has been reviewed by Mathew *et al.*(2008).

Seed propagation is resorted to in social or agro forestry plantings or as root stock. Since the seeds of both species are recalcitrant, these have to be sown fresh without drying. In kokum, seeds will be available from April to June in the dry season and do not germinate readily in open fields and need hot moist conditions for germination. Freshly extracted seeds are needed for best germination. Presowing treatment of kokum seeds with wet packing or drying with coal ash is good for germination. Tying the seeds in a cloth bag and watering for 8 days before sowing in seed pans filled with soil: cow dung: sand: in 2:1:1 proportion in a poly house combined with watering daily gives 80-90% germination. Three month old seedling are ready for transplanting to poly bags. In the Konkan region bigger seeds are extracted, cleaned and soaked in water for two days and sown in poly bags which gives 90% germination. Two seeds are sown per bag and the most vigorous seedling is retained. A bag size of 20cmX12.5cm. is ideal and a mixture of 2 part soil and 1 part FYM is sufficient.

In Malabar tamarind seeds are available from June – August. Extracted seeds are washed and spread on the floor of a shed for 20 days and sown in beds or in bags (2 seeds/bag). The best way to keep viability is by keeping them in moist sand intact for 1 year. The seeds remain dormant for about 10 months before germination if seed coat is not removed. If seed coat is removed germination takes place within 20-25 days and soaking with GA 3 (250ppm) can enhance germination. Another method is keeping seeds in a poly bag of 25x20cm size (500-750 seeds) with 30 – 50 ml. water and tying the bag airtight and keeping; germination takes place with in 10-12 days. Germinated seeds can be sown in bags or in beds. If bed planting is taken up transplanting of seedlings at 2leaf stage is to be done to avoid tap root injury. Seedlings of 12-14 months old in kokum and 7months old in Malabar tamarind are suitable for planting in field.

Vegetative propagation

Softwood grafting by the wedge method has been found to be the best for kokum and Malabar tamarind though root suckers also may be used. Due to branch dimorphism, the grafts exhibit bushy, horizontal or viny growth attributed to reduced auxin production and weak apical dominance. This habit may be useful in high density planting. To overcome this, orthotropic shoots arising from main trunk can be used as scions. The position of scion on the mother tree also influences growth of grafts. A study in kokum indicated that orthotropic shoots from top portion of trunk resulted in normal erect growing grafts whereas scions from lower portions resulted in viny growth (Waghmare *et al*. 2001). The best time for grafting in kokum is between October-November and March-August giving 70-85% success; best results are obtained in poly houses. A scion length of 10-12.5cm and thickness of 0.5-0.6 cm. defoliated 4-6 days before grafting and retention of four leaves on the root stock are helpful for better success in grafting. Scions of kokum can be stored for 7days wrapped in moss enclosed with a poly bag or can be kept safely in refrigerator. The ideal age of seedlings of kokum as root stocks is 8months when it attains 15-20cm. height. Seedlings of kokum is the best root stock for kokum though *G. gummigutta* and *G. cowa* are compatible.

In Malabar tamarind approach grafting and soft wood grafting are feasible but the latter is easy to do. The best season is June-October though grafting is possible throughout the year. The ideal scion is 3-4month old shoots of 15cm.length, light green colour and precuring is not required. Primary branches with whorled leaf arrangement are the best. Partial removal of leaves can be done at grafting time. Age of seedling can be 12months old. Seedlings of Malabar tamarind and *G. cowa* are equally good as root stock. Top working of Malabar tamarind is suggested to convert non bearing trees wherein trees are beheaded in February-March and the emerging shoots are cleft grafted with scions from good mother trees in the rainy season. The same method is also known as coppice grafting in kokum in which excess male trees are converted to productive ones.

Nutmeg (*Myristica fragrance* Houtt.)

Introduced from the Moluccas, the nutmeg yields two spices, the seed as nutmeg and the aril covering the seed as mace. According to Spices Board the area under cultivation is 13709 ha with a production of 11564 tonnes. The cultivation is expanding due to prevailing high prices and demand for planting material is very high. Though it needs a warm humid tropical climate it can be cultivated in some pockets of Deccan under the shade of coconut or areca nut with irrigation and protection from dry wind.

Improved varieties are Konkan Sugandha, Konkan Swad, Konkan Sreemanti (released in Maharashtra) and Viswasree released from Indian Institute of Spices Research, Kerala. The last variety is outstanding with very high yields and highest content of myristicine and is very popular with an acute shortage of grafted plants.

Propagation

The seeds of nutmeg are recalcitrant. Seed propagation was in vogue previously but due to better awareness on quality and yield vegetative propagation is increasingly practiced. Besides, the seedling progeny exhibits male and female trees in equal proportions and identification of sex at seedling stage is difficult (Krishnamoorthy *et al*. 1996). In order to get high yielding plantations of good grade vegetative propagation is essential. However seed propagation is necessary for root stock purposes and also in types bearing bisexual flowers on the same plant breeding true to type. Seed viability being low sowing immediately after harvest is needed. Storing seeds in moist sand moss or poly bags are helpful to extend viability period. Sowing can be done in containers or in sand beds and germination starts from fourth week onwards which may extend up to 3months. High germination has been observed in seeds from early harvest and also from female trees near male trees. Germination is also influenced by genotype. Transplanting is necessary immediately after sprouting to avoid tap root injury. A poly bag size of 25x 15cm. is ideal with potting mixture of 3:1:1 proportion of soil, cow dung and sand. One year old seedlings are ready for planting in the field or for budding. The literature on research on propagation carried out in nutmeg has been reviewed by Haldanker *et al*. (2008).

Vegetative propagation

Due to variation in seedling progenies for yield, quality and dioceous nature, vegetative propagation is essential in nutmeg. Grafting, budding, rooting of cuttings and layering are reported in nutmeg. Branch dimorphism with orthotropy and plagiotropy in shoots is significant in nutmeg propagation. In order to get erect growing trees orthotropic scions are to be used for grafting since plagiotropic scions result in bushy spreading trees though the latter may be useful for high density planting if trained properly. Whenever female grafts are planted male grafts also are to be planted in the proportion of 12female:1male to ensure satisfactory pollination. Alternately a male branch has to be grafted to each female tree for the same purpose. All efforts to reverse the plagiotropic nature of the grafts to orthotropy through physical or chemical means has not been succesful (IISR, 2011) though farmers report development of orthotropic shoot from plagiotropic grafts. Lack of availability of orthotropic scions for grafting or budding is a big problem and hence intensive efforts are needed to reverse plagitropy in the grafts.

Rooting of cuttings, layering, epicotyl grafting, inarching and approach grafting, budding and top working are reported in nutmeg. All attempts to root cuttings has not been very successful and layering was reported from Trinidad. However it has not reached to a commercial level. More research is needed in this line to produce uniform clonal material for research and as root stock.

Inarching and approach grafting on nutmeg and 6 other related species were reported (Aiyadurai, 1966) but the survival were poor and the method was costly. Epicotyl grafting has been standardized and recommended for large scale multiplication (Mathew 2008). In this method germinating seeds are used as rootstock before the leaves expand; both orthotropic as well as plagiotropic scions can be used. No precuring is needed but 3 or 4 leaves are retained on the green scions to improve success (80%) and the grafts are ready in one year for planting. Plagiotropic scions are used in view of the scarcity of orthotropic shoots and these grafts may be planted at closer spacing and trained to a height of 4 meters. Normally reversal of the plagiotropy does not take place but such shoots may arise by bending treatment (Mathew, 1985). Wherever the scions failed in epicotyl grafting the rootstock may be allowed to grow and later on can be grafted by the softwood grafting method. Epicotyl grafting can be successfully done on the related species *M.beddomei* and *M.malabarica* also.

Budding is the common method used by nurserymen though the success is low (20-30%) it economise scion material. One year old seedlings raised in big bags are used for budding and the method resorted to is patch budding though green budding with retention of leaves is also common on seedlings less than one year old. In budding only orthotropic scions are used that results in erect growing grafts and are sold at high cost due the dearth of good mother trees. In order to reduce the cost of budded plants *in situ* budding of field planted seedlings in a plantation can be taken up. However lack of trained or experienced budders is a problem faced by farmers. Top working can be done to convert excess male or low yielding trees by budding (Beena & Kurian, 1996). Whenever male trees are top worked one whorl of lower branches may be retained below the budded stem to provide enough pollen in a plantation. Though nutmeg could be grafted successfully on *M. beddomei* and *M. malabarica* long term performance on these rootstocks is yet to be studied.

Clove (*Syzygium aromaticum* L. Merr. & Perry)

The clove of commerce is the dried unopened flower bud of the ever green tree Syzygium aromaticum native tyo the Mollucas. Clove has been very important in world trade from ancient times and used in cuisine, medicine, perfumery etc. Being sensitive to soil and climatic conditions its scope in Deccan is limited but may be grown in selected areas with adequate protection. There are no known varieties but variations are seen such as king clove, dwarf clove, lillIput clove apart from yield differences in India. The Penang clove is considered superior world wide followed by Zanzibar and Madagascar. An ideal clove tree is regular and heavy in bearing, dwarf or bushy in growth with bold flower buds having high oil content.

Propagation

Clove is generally propagated through seeds called as mother of cloves. The available research work on propagation has been compiled and reviewed by Prasath and Parthasarathy (2008). Clove is self pollinated and seedlings come true to type from seed. Generally seeds become available in June. Immediately after extraction seeds are sown since the viability is lost with in a week. Large seeds give better germination. Sowing seeds in horizontal position with micropylar and facing side ways germinate better than vertical or inverted sowing. Low temperature is reported to slow down rate of germination. Germination is seen with in 15days. Removal of the seed coat has been found to enhance germination. Studies also indicate that hormones such as IBA, IAA, GA3 increase germination. Seeds may be stored at lower temperature to keep viability. Incubation of seed with sand or saw dust @ 5 to 10% jalasakthi and keeping in poly bags bound loosely has been reported to keep viability for 3 months.

Sowing of seeds is done in nursery beds or in poly bags to a depth of 2 cms. The medium consisting of soil, sand and cow dung in 1:1:1 or sand and cow dung alone is sufficient to get good germination. Mulching and regular watering are essential. As soon as the seeds germinate the seedlings are transplanted to poly bags of 25x15cms with a potting mixture of soil, sand, FYM in 3:3:1 and kept in nursery sheds and watered regularly. Alternately a mixture of vermy compost and soil in 1:1 proportion may be used which is reported to give enhanced seedling growth. The seedlings are ready for planting when 18-24 months old. Transplanting of seedlings is to be done very carefully owing to its sensitive root system preferably on a cloudy or rainy day.

Vegetative propagation

Due to low meristematic activity vegetative propagation is difficult in clove though rooting of cuttings, air layering and approach grafting are reported. Though rooting of cuttings was reported elsewhere efforts to root various types of cuttings even with hormones was a failure at IISR, Kozhikode. Good success with air layering of young shoots is reported with the use of IBA, IAA and NAA but the survival of layers in the field were poor and the method appeared not promising.

Approach grafting is reported to be very successful in clove performable throughout the year with 87% success in September – November. Though less successful, epicotyl grafting, soft wood grafting and cleft grafting are also reported to be feasible in clove. Budding has not been very encouraging.

Grafting of clove on 27 related species of clove is reported from abroad for dwarfing effect whereas successful unions were obtained with *S.cuminii* and *S.heynianum* in India. Dwarf clove as root stock was also tried which influenced scion growth. The purpose of interspecific grafting is to reduce canopy size for easy harvesting. However no long term studies are available to utilize these species commercially.

All spice (*Pimenta dioica* L.)

Allspice is a polygamodioecious tree that provides the pimento of commerce which is the dried unripe fruit. The flavour is a combination of the flavors of clove, cinnamon and nutmeg and hence the name. The dried berries, berry oil and oleoresin are used in food, medicine and perfume industries. The scope of its cultivation in the Deccan is limited except as one or two trees in homesteads for the leaves or the berries in local cuisine.

There are no known varieties in allspice. The tree produces hermaphrodite flowers but 50% of trees turn out to be functionally male. Hence grafts from yielding trees are to be planted for getting fruits. The tree also requires cold climate for flowering that takes place in December-January.

Propagation

Allspice is traditionally propagated through seeds. The available information on propagation on this tree has been reviewed by Krishnamoorthy *et al*. (2008). Seeds are extracted from ripe fruits by soaking in water overnight and rubbing in a sieve to remove the pulp. The seeds loose viability quickly and hence sown immediately in moist sand beds. The seed bed can be mulched with straw to retain moisture. The seed may be stored for nine weeks at 21-30degree centigrade to keep viability to 50%. The seeds germinate with in 10 days and may go up to 1month. Seedlings are planted in poly bags of 25 x 15 cm size containing soil, sand and cow dung mixture @ 3:3:1 proportion when 3-4 leaves appear. Seedlings of 10 month old are ready for planting.

Vegetative propagation

Vegetative propagation is necessary to get high yielding trees due to the male and female functionality of seedlings. Rooting of semi-hardwood cuttings is possible in 7-8 months with hormonal application. Air layering of semi-hardwood and softwood shoots with IBA and NAA at 4ooo ppm each has been successful. Rooting is a slow process and takes 18-28 months. Chip budding is also possible but the success is only 30%.In Jamaica approach grafting on allspice itself was highly successful (90%) and also in India. Grafting appears to be more commercially viable technique for adoption.

Curry leaf (*Murraya koenigii*)

Curry leaf is classified as a minor spice and is native to India which is the largest producer and consumer according to Spices Board. About 509 ha are cultivated in India and around 106 tonnes of curry leaf is exported annually. It is used as condiment rather than spice and finds an important roll in folk medicine. There is ample scope for extending cultivation of curry leaf in view of export market prevailing.

The existing diversity of curry leaf has not been exploited. Nevertheless a few clones have been selected. Suvasini-(DWD-1) is a veriety released in Karnataka with dark green leaves and a strong aroma; DWD 2 is seedling progeny with ash green leaves and less aroma; Savadathi Local and Old Garden Seedling with less vigour and small leave are other verieties known (Bhagavantha goudra and Madalagiri, 2001).

Propagation

Propagation aspect of this crop has been reviewed by Parthasarathy *et al*. (2008). Generally seeds are used for propagation. Being recalcitrant seeds are sown immediately after extraction in raised beds at 10 cm spacing. Storing of seeds with carbendazim treatment (1 gm/kg) at 10^{o} C in plastic bags recorded better germination. Germination takes place within five days. Two to three week old seedlings are transplanted to poly bags with a potting mixture of 3:1:1 soil sand and dry cow dung. One year old seedlings are ready for field planting.

Vegetative propagation through cuttings is successful in curry leaf. In a study of soft wood semi hard wood and hard wood cuttings hard wood cuttings rooted better and it was associated with high dry matter and starch content; high levels of protein and phenol in the cuttings were negatively correlated with rooting of cuttings. Cuttings from the past season shoots in May were the best for rooting of cuttings. IBA at higher level has been reported to increase not only rooting but the survival of cutting also. A lot of root suckers are produced around older plants and are useful for planting. Application of spent slurry to the plant is reported to enhance production of root suckers. Improved varieties can be propagated through rooting hard wood cuttings or suckers based on study conducted so far. How ever survival and performance in the long run need to be elucidated.

True cinnamon (*Cinnamomum zeylanicum*)
Tejpat (*Cinnamomum tamala*)
Cassia (*Cinnamomum aromaticum*)

Among the cinnamon species true cinnamon, and tejpat can be successfully grown in the Deccan.*C aromaticum* is not promoted as it contains coumarin reported to be carcinogenic. True cinnamon and tejpat are used in every household in south India for flavouring food. These may be grown in the open or as intercrop between areca nut and coconut with irrigation. Since seedlings show variation in bark quality it is advised to grow released varieties with better quality bark having high oil content and good yields. Crop improvement work has been done only on *C. zeylanicum* and Konkan tej, IISR Navasree, IISR Nithyasree, YCD 1, PPI(C)1, RRLB C-6 and Suganthini have been released (Rema and

Leela, 2008). These varieties possess bark oil ranging from 0.94% to 3.2%, leaf oil from 0.8% to 3.3% and yield of up to 200 kg dry bark per ha. No variety is available in tejpat with better quality leaf or bark.

Propagation

The research work on propagation of cinnamon has been reviewed by Rema and Leela (2008). Seeds of cinnamon species are recalcitrant and hence lose viability quickly. Ripe fruits will be generally available from June to August and are collected washed free of pulp and sown immediately since viability is low. Beds of sand or poly bags filled with potting mixture of 3:1:1 (soil: sand: dry cow dung) is used as the medium. Germination will start with in twenty days. Transplanting of seedlings in beds is required as soon as sprouting is seen. Shading for seedlings is required up to 6 months in the nursery. One year old seedling can be planted in the field.

Vegetative propagation

Being a cross pollinated crop seedlings show variation for bark yield, oil contend and other quality aspects. Since good verieties have been released clonal material has to be planted to improve the plantations. Rooting of cuttings and layering can be successfully done in cinnamon and no other conventional method of vegetative propagation is reported. Tissue culture of cinnamon has been reported but it is not reached to the level of commercial use. Single nodded cuttings with one or two leaves could be made to root within 40 days under humid condition and use of IBA and IAA @ 2000 ppm will enhance rooting. Variation has been observed between genotype for rooting response and also effect of seasons. This may be due to the physiology of the planting material used. Similar results have been observed in cassia also.

Air layering of semi hard wood shoots is very successful in cinnamon; sphagnum moss has been found to be the best medium for rooting and hormones such as IBA, NAA and phenolic compound gallic acid are also reported to improve rooting. Seasonal variations also has been observed in rooting of layers, the best rooting obtained in July followed by June. Air layering is successful in cassia also. How ever layering is done to obtain bigger plants in a short time than cuttings which takes more time to reach plantable size. However rooting cuttings is ideal for economising material and is quiet easy.

Though no research on vegetative propagation on *C.tamala* has been done, rooting of cuttings and air layering are quiet possible in this species. How ever, no standard variety has been recognised in this and seedling propagation may be resorted to raise new trees for which the methods are the same as practiced for cinnamon.

Conclusions

Though various tree spices are grown in the country, tamarind, garcinia, nutmeg, cinnamon,and curry leaf are suited to the agro climate of Deccan but all spice and clove may be grown in selected pockets with protection. Tamarind is well suited and extensively grown in the region through seedlings but now improved varieties are available. Vegetative propagation methods are available especially soft wood grafting which is amenable for large scale multiplication of these clones and it is only a question of time to bring more areas under the improved varieties. Since the crop is having great potential commercially making grafted material available is the task ahead and all efforts be made to realise this. Budding can be taken up for top working of nondescript trees in plantations to improve yield and quality. Training of rural youth is what is needed to realise the potential.

Among he garcinias kokum offers good scop in the region since it is a new introduction, along with grafted plants. Male plants also need to be introduced since only female plants give fruits. Here also soft wood grafting can play a vital role in spreading the crop. Nutmeg is a good choice as inter crop in coconut and areca nut plantations with irrigation. Grafted plants of viswasree have to be introduced with male plants to get good yields. Intensive work need to be done on induction of orthotropy in plagiotropic shoots to scale up production of orthotropic grafts. In situ budding on field planted seedlings also need more studies to reduce cost of planting material.

Cinnamon especially true cinnamon has immense scope in the region. Since rooting cuttings with single node is easy improved varieties can be introduced and large scale multiplication can be done through mist chambers and supplied to planters. Since cassia is banned from import the scope is increased along with new medical findings on cinnamon. Air layering may not be an economical method of using planting material.

Curry leaf is also having good potential because it is already grown. But the improved varieties are yet to reach growers. Rooting hard wood cuttings or induction of suckering on a large scale may be adopted to increase spread of the aromatic varieties.

All spice and clove have only limited scope in the Deccan. Nevertheless, planting may be taken up in homesteads under protection with fertile types for better fruiting. In the current scenario of global weather changes it is likely that some of these spices like clove may become scarce and encouraging its cultivation to non traditional area may be worth trying.

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Quality planting materials in herbal spices - Problems and prospects

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The history of spices dates back to the beginning of human civilization**.** Herbs and spices are probably the most widely grown aromatic group of plants all over the world today. The botanical definition of the herb is a plant with no persistent stem above ground and for all practical purposes; herbs are those plants with aromatic or perfumed parts, whether they are leaves, roots, flowers or fruits which are used as ingredients in food, beverages, medicines, perfumery and cosmetics. A large number of herbs and spices are also used as ornamental as well as garden plants. Based on the life span , herbs are categorized in to annuals, biennials and perennials plants and these group of plants possess antioxidant, antimicrobial, pharmaceutical and nutritional properties. Culinary herbs are usually distinguished from spices and generally consist of fresh or dried leaves which imparts mild flavor unlike spices which provide strong and pungent flavor. Most of the culinary herbs belong to the families of Apiaceae and Lamiaceae. The Mediterranean areas including North Africa and Middle East are considered to be the centre origin of most of the culinary herbs including bay leaves, cumin, coriander, mustard, rosemary and sage. The colder regions of north Europe and Asia have supplied only few herbs like caraway seed and horse radish. Now many herbs are extensively cultivated in different countries like France, Egypt, Hungary, Indonesia, USA, UK, Turkey and Algeria .The total consumption of the dried herbal spices is estimated as 30000 – 32000 M.T./ annum in the international market. The major suppliers are France, Germany, Netherlands, Turkey, Mexico, Greece, Israel, Egypt, Hungary, Albania, Yugoslavia, Spainand Morocco. The major markets are West Europe and USA importing about 12000 - 13000 M.T. each year.

Indian scenario

The cultivation of herbal spices is presently confined to a few pockets at higher elevations of Tamil Nadu, Jammu and Kashmir, Rajasthan, Delhi and Uttar Pradesh. Among the culinary herbs, mint occupies a prime position in India. Its cultivation is spread over to many states in the country. During 2010- 11 seasons, the export of spices from India registered an all time record both in quantity and value. Among the spice commodities Mint products including Mint oils, Menthol and Menthol crystals made a contribution in forgein exchange earnings to the tune of Rs 169679 lakhs. Many of the herbs are cultivated on small holdings and are scattered, accurate information on area of cultivation; production and productivity are not available. Green house cultivation is also practiced on commercial scale however, field grown organically produced herbs are widely preferred in the market. It is estimated that India requires 200 MT of herbal spices annually, out of which around 65 MT are produced, The bulk of the consumption is accounted by the metropolitan cities like Delhi, Mumbai, Calcutta and Chennai. In recent years the cultivation of herbs is in the increasing trend. However, the domestic demand is met through the imports. The import cost of herbs is very high in India and this warrants its large scale cultivation. Since the Indian sub continent is blessed with congenial climatic conditions suitable for the cultivation of herbs through out the year, its cultivation shall be extended to large areas in North Eastern states of India in the near future.

The Indian sub-continent is blessed with large natural resources, minerals and most importantly with unique physiographic, edaphic, climatic and altitude gradients. The diverse agro climatic conditions prevailing in the country favor the cultivation of a wide range of spices. There is an ample scope for commercial cultivation of exotic herbal spices owing to many favorable factors particularly their amenability to organic system of cultivation and even at small land holdings these crops could be cultivated profitably.

Cultivation – prospects and potential

Herbs as a group are relatively easy to grow. However the optimum growing conditions vary with each individual herb. Generally herbs grow best in soils with excellent drainage, bright sun and moderate temperature. The cultivation of diverse groups of herbs would be ideal as it helps to keep the pest problems minimum.

An array of variability has been encountered in the growth habit and morphology of the useful part(s) of herbal spices. Some are succulents (parsley, celery), bulbs (leek, chives), small creepers (marjoram, thyme), root tuber (Horse radish), hardy shrubs (rosemary, lemon thyme) and even woody tree (bay tree). The morphology of the useful parts varies with the herb. It can be root (horse radish), stem (sweet marjoram), leaf (bay, oregano, mint, parsley, thyme, and tarragon), flower (hyssop) and seed (caraway, anise, poppy). The wild populations of these herbs may have high degree of genetic variability, as unmitigated genetic recombination, gene erosion and mutation which can occur in its natural habitat.

There is a tremendous potential for export of these spices from India particularly in value added form. Some of the spices are commercially cultivated and others are on trial basis at various locations. According to estimates India cultivates 15,000 ha of Japanese Mint, 1,200 ha of Spear Mint and 300 ha of Pepper Mint and produce annually 100t of each of the former two and 29t of the latter. The Menthol content is high in the Mint grown in the tropics. However, its extensive cultivation in India is beset many constraints. It includes lack of adequate good quality planting materials, good agricultural practices (GAP)for quality commodity production, inadequate storage facilities for up keeping the quality of raw as well as processed products, lack of market linked production and unawareness of its potential and suitability under Indian conditions, etc.

Planting material's production

Most of the herbal spices cultivated in the country are introduced ones and lots of limitations are encountered in the isolation and identification of improved varieties of exotic spices unlike native ones. Research organizations in the country have come out with improved / released varieties in many endemic herbs for commercial cultivation. A large number of potential herbs of exotic origin have been identified for commercial cultivation in the country owing to its export potential and influence in the employment generation and socio – economic development of the inhabitants. The availability of these herbs for large scale cultivation is an issue to be addressed with different approaches including plant introduction, traditional propagation methods and biotechnological interventions.

Plant Introduction: The process of plant introduction becomes very efficient and successful when the magnitude of variability is enormous in the candidate species. The selection of improved varieties / ecotypes in herbs at its source of origin would be imperative approach to be worked upon owing to specific environmental limits for growth, development and synthesis of active principal constituents. Such selected types should be introduced for domestication in areas identified for cultivation. As the search for novel and innovative products of herbs continues, the need for introduction and cultivation of increasing number of ecotypes / improved varieties will remain an integral process in the final processing, utilization and availability.

Propagation methods: The propagation methods employed vary with the herbs and some of them respond well to sexual reproduction through seeds. Raising of plants directly from seed source often causes problems due to various factors. Seed sowing in the ground can be unreliable and seed germination rate are disappointing owing to small seed size. A high percentage of newly sprouted plants damp off or wither away under adverse conditions. Further other young plants may succumb to insect pests. Considering these issues, it is imperative to sprout seeds in small containers, indoors or in shaded conditions. A mix of peat and sand or sterile potting soil should be used as the planting medium.

Vegetative propagation is by and large widely preferred in majority of herbs such as mint. Celery, parsley, oregano etc. and this assures the production of quality planting materials. Various methods are employed depending upon the nature of the crop. In colony forming herbs like thyme, oregano; the clumps are subdivided for multiplication. The crops like sage and rosemary, air layering or grafting techniques could also be employed for propagation. Air layering is accomplished by scrapping away a portion of bark on a branch, wrapping the same in damp Sphagnum moss and scaling the wrap in cellophane covered aluminum foil or any other suitable device. After the root formation within the Sphagnum moss, the branch is removed from the stock and replanted. Grafting involves joining a scion with the root stock, which is typically a young seedling plant from the same species. In crops like rosemary, ground layering can be employed for propagation. It involves bending over a flexible stem, scrapping away some bark to expose the cambium and buried the exposed portion in a round of earth with the branch tip protruding. After a few weeks, roots will form along the buried section of the stems. At the point the stems can be severed from rest of the plant and used for planting.

In woody types, rooting of soft wood cuttings can be attempted. The desirable branch should be severed with a sharp knife about 4- 6 inches below the ground tip. A diagonal cut made just below a node will promote rooting. After removing the leaves from the basal portion, the cuttings should be dipped in rooting hormone before being planted in the growth medium. A mix of damp sand and peat works well as medium. Providing nest chambers to maintain high humidity will promote growth.

Conventional propagation through stem cuttings or through seeds is slow and therefore *in vitro* propagation is also to be employed for the commercial production of planting materials. The protocol for *in vitro* propagation of these spice crops has already been standardized by various National Research Institutions such as CIMAP, Luknow, IISR, Calicut and Agricultural Universities. The technology can also be made use for the large scale production of planting materials. In event of severe transmission of viral diseases through cuttings, micro propagation techniques can be advantageously resorted to under such conditions, provided the explants are collected from gardens which have identified as free of virus diseases.

Potential herbs

The rich resources reservoir and ideal climatic conditions prevailing in India provides a favorable niche for the growth and commercial cultivation of herbal spices. The demand for Menthol mint, Marjoram, Oregano, Sage, Thyme and Bay leaves is relatively high compared with other herbs. Apart from these a very few herbs of exotic origin has a great potential in the national and international markets. Some of the economically viable and suitable for large scale cultivation are described.

Majoram (*Majorana hortensis*. Moench, Family: *Lamiaceae*)

Majoram, the perennial aromatic herb is a native of Mediterranean region and extensively cultivated in India. Its leaves and seeds are astringent and are used in flavoring liver preparations and polish sausage and chees, in soaps, salads, egg and vegetable dishes. Its leaves are used foe seasoning food. It yields 3.5% volatile oil. Propagation is through both seeds and cuttings. The plant has also been employed in the treatment of cancer and also exhibited antifungal activity.

Mint and pepper mint (*Mentha piperita* L., Family: *Lamiaceae*)

Mints are best known herbs. Mint is a native of Europe and Asia and introduced throughout the world due to its wide adaptability. Mints are tropical perennial members. Botanically the Pepper Mint (*Mentha piperita*) represents a hybrid between *M. spicata* and *M. aquatica*. The garden mint is *M. spicata*. As these herbs rarely produce viable seeds, propagation is done mainly by divisions of stolons or easily rooted cuttings. They are laid end to end in furrows, 5 Cm deep and 60 Cm apart and covered with soil. In the first year the rows will retain its identity and subsequently the plants will spread over the field.

Replanting is necessary after four to five years of growth. The fresh leaves are used for making chutney. It is also used in flavoring meat, fish soups etc. Pepper mint oil is used in co confectionary and liquors, pharmaceuticals and dental preparations. The oil and dried plant parts are antiseptic, carminative, stimulant and diuretic.

Oregano (*Origanum vulgare*.Linn, Family: *Lamiaceae*)

The perennial plant Origanum is indigenous to the Mediterranean region particularly Greece, Italy and Spain. It grows well on sunny, slopping hilly areas surrounding the Mediterranean. In India, it is produced on a small scale and grown in the Shimla hills, Kashmir valley and Nilgiris. It is a perennial plant. The dried herb is pale grayish green in color. The crop is harvested when in full bloom. It has a strong aromatic, camphorccous flavor. The dried leaves, stalks and floral parts all constitute the spice. It is propagated through seeds and cuttings.

Parsley (*Petroselinum crispum* (*P. milles*), Family: *Apiaceae*)

Parsley is a most expensive culinary spice indigenous to the Mediterranean. Parsley is a dried, aromatic leaf of a low growing biennial herb with dense foliage and white flowers. The bright green leaves are finely divided and cured; it has a warm, fresh herbaceous flavor. It contains vitamins A, B & C and many other nutrients. Dried parsley flakes are used for seasoning a variety of food. It also finds use in beverages and medicines and dried roots and leaves used insecticides. Parsley is propagated through seeds.

Rosemary (*Rosmarinus officinalis*. Linn., Family: *Lamiaceae*)

Rosemary is indigenous to European countries bordering the Mediterranean. In Indian Rosemary is grown in homestead nature. Rosemary is the leaf of densely branched, small, evergreen aromatic shrub that may grown up to height of 2 meters, The shrub produces linear, leathery, dark green leaves with light sky-blue flowers. When dry the leaves have a rolled up appearance, dark green color and teas like fragrance. It is propagated by cuttings. Commercial Rosemary production is being commenced in the Nilgiri district of Tamil Nadu in India.

Sage (*Salvia officinalis* Linn., Family: *Lamiaceae*)

Sage is native of southern Europe and it is a bushy perennial shrub. Sage has been widely used in the food industry as a standard spice in marketing stuffing of fowl, meat and sausages. It is used as a mild tonic, astringent and carminative and in toothpaste, mouthwash, toothpowder, hair tonics etc. Sage has been prescribed to cure female disorders since ancient times. Sage oil is used in perfumes as a deodorant apart from insecticide preparations. It is harvested top growth before flowering and it yields 2.5% essential oil. It is propagated through stem cuttings.

Savory (*Satureja hortensis* Linn., Family: *Lamiaceae*)

Savory is one of the most fragrant spices. It is an erect pubescent annual herb native of southern Europe. It is propagated through seeds. Savory is used in flavoring of soups and sauces, egg and salad dishes apart from poultry dressing. Savory is of two types. Winter savory (*Satureja hortensis*) summer savory (*Satureja montana*. It contains 1% volatile oil. The herb is reported to have carminative and stimulating properties and it is also possess anti-oxidant property.

Tarragon (*Artemisia draccunculus*. Linn., Family: *Asteraceae*)

The dried leaves and flowering tops of *Artemisia draccunculus* form the tarragon of commerce. It is a perennial herb native of West Asia and Southern Europe. Tarragon is used for flavoring vinegar, pickles and to a limited extent for the flavoring of soups, salads and vegetables. The aromatic leaves are employed in the preparations of the medicine. Harvest young leaves and shoots before flower buds develop and it yields 0.3 to1.3% of oil. Its aroma is warming aromatic and reminiscent of anise. It is vegetatively propagated through cuttings

Thyme (*Thymus vulgaris*, Family: *Lamiaceae*)

It is indigenous to the Mediterranean region. In India, thyme grows wild along the western Himalaya region, from Kashmir to Kumaon. It is also grown as homestead gardens in Ooty. Thyme is flourishes in sub- tropical and temperate climates. Thyme has a pungent, mint like odour. Thyme is small, creeping shrub like perennial. It has dense, whitish branches bearing narrow leaves and clusters of purple leaves. The leaves and flowering tops are used as spice, but the entire plant, excluding the roots yield oils and oleoresins. Propagation is by means of seeds and cuttings.

Basil or sweet basil (*Ocimum basilicum* Linn., Family: *Lamiaceae*)

Basil is the dried leaf of a tropical annual, erect glabrous herbaceous plant, native of Northwest India and Persia. In India, there is a wide spread belief that if planted around home and temple, it ensures happiness. Polymorphism and cross pollination under cultivation have given rise to number of sub – species, varieties and races. The leaves have numerous dots like oil glands which the volatile oil of the herb is contained. Basil contains protein, volatile oil, fixed oil, cellulose pigment, minerals and vitamin. It is propagated through seeds. The essential oil has found important application in perfumery and leaves are used in flavoring food. It is a very safe insect controlling agent.

Demonstration of herbal spices farming

Spices Board has taken up a UNDP financed project on **'**Integrated Development of Spice Industry'**.** Organic farming of spices was identified as one of the components in which pepper, ginger, turmeric, vanilla etc. and herbal spices like Rosemary, Thyme, Parsley included. *Non Governmental Organizations* (NGOs) such as Peermade Development Society (PDS), Wyanadu Social Service Society, Kerala, HOPE, Nilgris ,Tamil Nadu were entrusted implement the scheme on participatory mode approach. During the IX Plan, Spices Board has implemented a pilot project for development of herbal spices with the support of NGO viz. HOPE in Nilgiris, Tamilnadu. The project has successfully demonstrated the commercial cultivation of herbal spices viz. Rosemary, Thyme etc by the beneficiaries. Prior to implementation of the project the cultivation of herbs in Nilgiris was limited to a small area (few cents) mainly for supply of fresh herbs to Star hotels in major cities. Apart from the standardization of production technology, the project could demonstrate post harvest practices such as scientific processing and value addition. Rosemary and thyme oils were extracted and made available in the domestic and export market. The programme has become very successful replicable model.

Considering the successful outcome of the project, the Board has implemented the herbal spices development programme during X plan with the active support of NGOs / Farmers Groups to cover 50 ha by meeting 40 % of the cost of planting materials as subsidy. Under this scheme, the cultivation Rosemary was extended to Burgur hills in Erode District of Tamil Nadu covering 38 ha covering 105 small and marginal growers with the support of HOPE, Farmers group, Myrada KVK, DRDA. The facilities for drying as well as oil extraction were provided. It has revealed that Rosemary cultivation in Nilgris and Erode districts of TamilNadu became economically viable under organic system of cultivation. Further, it helped in the promotion of group farming by small and marginal growers. The successful model involving grower - exporter partnership with support of NGOs will provide benefit the entrepreneurs interested in herbal spices cultivation.

Conclusions

The demand for plant products of natural origin is in the increasing trend, herbal spices as a whole gained momentum all over the world particularly in the developed countries, these products are compatible with the human system and relatively less toxic compared to synthetic ones. The diverse agro climatic conditions and natural resources available in the country are highly suitable for large scale cultivation of these herbs. Further its cultivation under organic farming is very advantages and even homestead gardens or in small land holdings can also be brought under its cultivation.

Presently the large scale cultivation of these herbs is constrained due to the non availability of planting materials. Various methods are employed for the production of planting materials and are described elsewhere. Conventional methods through seeds and stem cuttings are very slow and therefore *in vitro* propagation is viable for the commercial production of planting materials. The protocol for the in vitro propagation of these crops has been standardized by National Research Institutions and Agricultural Universities. The large scale cultivation and production will pave way to concentrate on the product diversification and thereby, employment generation and socio – economic development of the inhabitants would also be improved. Further, the country could contribute chemical residue free commodity for domestic as well as export markets substantially.

Prospects of organic production system and health management in chilli

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Chilli (*Capsicum annuum* L.), a tropical and subtropical crop, is one of the major vegetable and spice crops grown in the country and is popular know as king of spices. It is an essential ingredient of Indian curry, which is characterized by tempting colour and titillating pungency. Both as green and dry chilli is used as paste, powder and as whole or in broken/split form. Chilli is a fascinating spice with two important commercial qualities, some varieties are famous for red colour because of the pigment capsanthin and others are known for biting pungency attributed by capsaicin. The pericarp contains almost all the pungency where as the chilli seeds contain traces of pungency. The capsaicin content in red dry chillies varies between 0.7 to 0.9 %. India is the only country wherein a large number of varieties of chilli are grown. Country earns tremendous foreign exchange from the export of spice chilli, oleoresin of low, medium or high pungency and chilli powder. India is the largest producer of chilli crop, grown over an area of 0.78 million ha with an annual production of 1.27 million tonnes with the productivity of 1630 kg ha^{-1}. Karnataka ranks second in area (0.16 million ha) and production (0.11 million tonnes) of dry chilli after Andhra Pradesh (Anon., 2008-09).

As per provisional estimate made by Commodity Watch Group, India exported around 0.17 million tonnes of chilli during 2007-08 and the value of the export was Rs.9.064 billion. There is no doubt, greater international demand of chillies would continue in the years to come (Anon., 2008).

India has become "World's largest producer and exporter of chilli" exporting to USA, Canada, UK, Saudi Arabia, Singapore, Malaysia, Germany and many countries across the world. Indian chillies have been dominating international chilli market. India producing 25% of the world total chilli production. Majority of chilli grown in India is cultivated in states such as Andhra Pradesh, Karnataka, Orissa, Gujarat, Maharastra, and Tamilnadu.

In the recent years there is lot of awareness and preference for organically produced food stuffs in the country. Both Government of India and Government of Karnataka have been earmarking significant amount of funds for popularizing organic farming techniques, especially in consumable crops. There is also tremendous demand for organic chilli especially cv. *Bydagi* in recent years. Apart from that, soil health and ecological balance are of paramount importance in switching over to organic farming from chemical based conventional agriculture. In this context use of organics like compost, vermicompost, poultry manure and neem cake, use of botanicals, biopesticides and polycropping need consideration.

Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including bio-diversity, biological cycles and soil biological activities. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking in to account that regional conditions required locally adopted systems. This is accomplished by using where possible agronomic, biological and mechanical methods as apposed to using synthetic nutrients to fulfill any specific function with in the system (FAO/ WHO Codex Alimetarius Commission, 1999).

Increasing awareness of the environmental impact of conventional high input intensive farming system has led to a move towards alternatives. Which explicitly acknowledge the externalities of farming systems mainly the fertilizers, pesticides, and energy. The organic (biological/ecological) approach is one of the alternatives to conventional production system currently being advocated (Subba Rao *et al*., 2007). Considering the potential environmental benefits of organic production and its compatibility with integrated farming approaches, quality of food, sustainability, organic agriculture is considered as a viable alternative for sustainable agricultural development (Ramesh *et al*., 2005).

Countries with data on certified organic agriculture during 2009 are 160 countries which were 86 during 2000 with organic agricultural land of 37.2 million hectares. Twenty four countries have more than five percent organic agricultural land. Further, non-agricultural organic areas during 2009 was 41.9 million hectares. Globally (2009) 1.8 million organic producers with India having 677'257 farm families involved in organic farming. Organic market size 54.9 billion US dollars with major consumers are US (15.2 billion US Dollars), Germany (5.8 billioneuros), France (3 billion euros). It is interesting to note that Food & Agricultural Organization (FAO) Committee on Agriculture, during the 15th Session, has discussed the topic, "Organic Agriculture" and concluded that FAO has the responsibility to give organic agriculture a legitimate place within sustainable agriculture programmes. In several developed countries, organic agriculture has come to represent a significant portion of food system (Austria, Switzerland) and many other countries such as Japan, Singapore, France, United State of America etc. are experiencing growth rates that exceed 20 percent annually (FAO Committee on Agriculture – Agenda Item 8, pages 1-12).

Many developing countries began to seize the lucrative export opportunities presented by organic agriculture (e.g., export of cotton from India, Uganda and many other countries, export of Mexican coffee, organic spices etc.). Although, it is yet in its infancy, organic farming is becoming important largely through the efforts of small groups of farmers. It has come out of the exploitative agriculture that has been followed by in all these years, resulting in damaging impacts on environment, human and animal health, soil and water resources. It is well known now that increased use of chemical pesticides (rather abuse) and fertilizers have created chain of problems of soil, environment and water degradation. The intensive chemical agriculture that has been followed after green revolution successes is causing heavy pollution of our food, drinking water, air and the quality of life which has substantially deteriorated. The rural economy is in ruins because of over-dependence of outside inputs in agriculture such as seed, fertilisers, pesticides, growth-promoting chemicals etc. It is even said that the chemical agriculture has destroyed our ability to think about the right way to go forward. In fact, Government of India has been clearly aware of the importance of organic farming approaches and emphasis on promotion of organically produced commodities, particularly in plantation crops, spices and condiments.

Chilli crop responds very well to organic production practices. Traditionally, byadagi chilli is grown without much chemical fertilizers and pesticides. Organic chilli has greater demand in international and domestic market. The field trials conducted under Network Project on Organic Farming (NPOF) at Main Agricultural Research Station, Dharwad revealed that, two years conversion is required to stabilize the yield under organic system (Tabel-1). The third year 2006-07 yield showed significant superiority with organic system, compared to inorganic system and at par with integrated system. Integrated and organic systems recorded significantly higher net returns compared to inorganic system (Babalad et al., 2009). Combined application of enriched compost, poultry manure and green leaf manure (gliricidia) equivalent to recommended 100 kg N per ha produced significantly higher chilli yield as compared to their individual application (Table-2).

Table 1. Performance evaluation of under organic farming chilli + cotton cropping system (pooled 2004, 2005 and 2006)

Treatment	Chilli yield (kg/ha)	Cotton yield (kg/ha)	Chilli equivalent yield (kg/ha)	Net returns
Organic	391	534	604	10070
Integrated	415	600	656	10257
Conventional	401	526	611	9072
CD @ 5%	NS	NS	NS	433.9

Table 2. Yield and economics of chilli + cotton system as influenced by organic nutrient management practices (pooled 2004, 2005 and 2006)

Treatment	Chilli yield (kg/ha)	Cotton yield (kg/ha)	Chilli equivalent yield (kg/ha)	Net returns (Rs / ha)
EC+GLM	385	540	608	15292
VC+GLM	436	553	628	14339
PM+GLM	466	554	691	17874
EC+VC+GLM	494	607	704	18023
EC+PM+GLM	515	601	688	19028
VC+PM+GLM	437	607	652	18652
Control	302	432	457	11896
LSD (0.05)	84.4	74.4	113.0	3652

After 3rd year (2006-07) of cropping season with chilli + cotton cropping system, the organic system showed improvement in soil physical properties like bulk density, maximum water holding capacity infiltration rate over inorganic system (Table-3). The significant increase in soil organic carbon (0.63%) with organic system compared to inorganic and conventional systems (0.58% and 0.55% respectively). The available nitrogen was comparable among the system, but significant increase in available phosphorus and potassium was observed over inorganic system (NPOF, 2008). At ICRISAT on farm and low cost organic systems showed higher available nitrogen and phosphorus and organic carbon as compared to chemical fertilization (Rupela *et al*., 2004). Organic system produced significant improvement in quality of soil mainly bulk density, maximum water capacity, infiltration rate, organic carbon available nitrogen, phosphorus and potassium (Babalad *et al*., 2009).

Table 3. Soil physical and chemical properties as influenced by different systems after third year in chilli + cotton cropping system (2006-07)

Treatments	Bulk Density (q/CG)	MWHC (%)	Infiltration rate (mm/hr)	Organic carbon (%)	Average nitrogen (kg/ha)	Average P_2O_5 (kgha)	Average K_2O (kg/ha)
Organic system	1.20	61.50	0.45	0.63	286.0	30.5	369.0
Integrated system	1.22	60.95	0.39	0.58	290.0	28.7	340.0
inorganic system	1.30	60.00	0.34	0.55	275.0	28.0	315.0
Initial values	1.28	60.00	0.30	0.43	250.0	16.5	330

Organic materials such as bio-digested slurry, poultry manure, green leaf manures and FYM can substitute for inorganic fertilizers to maintain productivity and environmental quality (Chaoudhary *et al*., 2002). Although the organic manures contain plant nutrients in small quantities as compared to the fertilizers, the presence of growth promoting principles like enzymes and hormones, besides plant nutrients make them essential for improvement of soil fertility and productivity (Bhuma, 2001).Application of biogas slurry + FYM, vermicompost + FYM, vermicompost alone have recorded maximum fruit size, more number of fruits per plant, while inorganic fertilizers (NPK) recorded the minimum fruit size. It is inferred that tomato crop would respond well to the application of organic manures either in combination with (Renuka and Ravishankar, 1998), Sheshadri and Prabhakara Shetty

(2002) recorded significantly higher dry chilli yield (765 kg per ha) with the application of poultry manure @ 3 t per ha when compared with 100 per cent RDF (739 kg per ha) and FYM @ 10 t per ha (652 kg per ha). The higher yield in poultry manure and RDF could be attributed to significantly higher values of yield components like number of fruits per plant, 100 fruit weight, fruit length and yield per plant.

Oleoresin is the extractant or essential volatile oil derived from spice. It is viscous semi solid gel like substance and is free from bacteria, spores and molds. It contains all the important quality characters present in chilli. Freshly prepared oleoresin has deep blood red colour and has its own flavour. Oleoresin permits uniform distribution of colour and flavour to the food. The yield of oleoresin from different chilli varieties range from 8 to 17.5 per cent.Oleresin can be stored for long time without any change in its composition unlike whole chilli.Due to this property, it has acquired great importance in industries. Oleoresin contains essential oils and non-volatile resins which are very important for its flavour. Three types of oleoresins can be prepared from chillies (Narayanan *et al.*, 1980). Shashidhara (2000), reported that per cent oleoresin content significantly increased with the application of organics (FYM/Biogas Spent Slurry/red gram stalk) and inorganics (100% RDF). The combined application of FYM + 100 per cent RDF, biogas spent slurry + 100 per cent RDF and red gram stalk + 100 per cent RDF increased the per cent oleoresin (16.63%, 16.81% and 16.85%, respectively) as compared to 100 per cent RDF alone.

At Dharwad, application of RDF + FYM @ 10 t per ha recorded significantly higher leaf area index (2.15) which was on par with FYM (50%) + poultry manure (50%) (2.06), RDF (100:50:50) (2.09) and vermicompost (50%) + poultry manure (50%) (2.03). Application of neem cake @ 4 t per ha recorded significantly lower leaf area index (1.23) and it was on par with vermicompost @ 10 t per ha (1.28) and farmyard manure @ 40 t per ha (1.09). Application of RDF along with FYM 10 t per ha recorded significantly higher dry fruit yield (772.26 kg ha-1) and it was on par with application of RDF (100:50:50) (737.98 kg ha-1), FYM (50%) + poultry manure (50%) (727.61 kg ha-1), vermicompost (50%) + poultry manure (50%) (713.51kg ha-1), FYM (50%) + neem cake (50%) (710.67 kg ha-1) and poultry manure @ 7.5 t per ha (708.23 kg ha-1) (Thimma Naik, 2006).

Variable levels of N and K and integrated nutrition to the chilli crop through organic and inorganic sources are also very important for the healthy growth of crop and for reducing the sucking pest complex. Vermicompost helps for better growth and development of the crop and imparts resistance to the crop against pest and diseases (Meerabai and Asha, 2001). While neem cake helps in reducing the sucking pests due to presence of bitter terpenoids mainly azadirachtin which is responsible for antifeedent, anti-ovipositional, growth disrupting, fecundity and fitness reducing properties of pests (Alam *et al.*, 1979).

The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in the field as well as in storage (Anon., 1987). Amongst these, aphids; *Myzus persicae* Sulzar and *Aphis gossypii* Glover., thrips-*Scirtothrips dorsalis* Hood., yellow mites-*Polyphagotarsonemus latus* Banks, and fruit borer - *Helicoverpa armigera* Hubner are the most vital production constraints. A total of 39 and 57 insect pests were recorded in Karnataka in chilli nursery and field crop, respectively (Reddy and Puttaswamy, 1983 and 1984). Interestingly, these insect pests respond differently to fertilization, particularly to nitrogen and potassium. Thrips, mites and aphids desap chilli crop resulting into leaf curling and petiole elongation (*murda* symptom) with the presence of viral diseases. As early as in 50s; Puttarudraiah (1959) reported the involvement of thrips and mite for the viral spread and for the cause of *murda* disease.

The yield loss due to thrips and mite is estimated to be over 50 per cent (Ahmed *et al.*, 1987). Pesticides are therefore used to combat these insect pests. During the last two decades insecticidal control of chilli pests especially in irrigated crop characterized by high pesticide usage as many as 6 to 20 rounds of chemical sprays (Lingappa et al., 2002 and Anon., 2006) has posed problem of destruction of natural enemies, pest resurgence and pesticide residues in the fruits (Joia *et al.*, 2001 and Smitha and Giraddi, 2006). Infact, both significant domestic consumption and sizable export of chilli necessitate production of quality chillies devoid of contamination of pesticides, industrial chemicals and aflatoxins. But the presence of residues in spices in general and in chilli in particular has been a major non-tariff barrier against export of chillies to the developed countries. The reported presence of residues of many insecticides including ethion, chlorpyriphos, cypermethrin, endosulfan and quinalphos has seriously affected the export of chillies. Chilli consignments are detained at the ports of the importing countries very often due to high pesticide usage in India. Hence, it is imperative to produce pesticide free chilli by adopting eco-friendly management practices. Several issues, therefore, need to be re-examined and put under evaluation so that sound management programme can be evolved with minimum or no pesticide spray. Since the pesticide consumption in the rainfed Cv. *Byadagi* chilli is increasing slowly and Byadagi chilli (dabbi) is being grown in large areas in the irrigated belts of Krishna river (N-W part of Karnataka) of the state, development of least chemical or no chemical package is the need of the hour for both rainfed and irrigated chilli ecosystems.

In fact, indiscriminate use of insecticides has led to insecticide resistance, pest resurgence, environmental pollution and upsetting of natural ecosystem (Lakhan Singh and Sanjeevkumar, 1998). To overcome these problems, use of biopesticide spray, plant based substances and certain indigenous practices offer safe alternatives in pest management (Narayanaswamy, 1999). Generally plants in leeward side recorded higher leaf area compared to the plants in the windward side. Barrier with six and nine rows recorded highest leaf area as compared to 3 rows. Among the species used as a barriers, chilli with fodder and grain sorghum (1762 and 1611 cm^2/hill) produced significantly higher leaf area.

Table 4. Leaf area (cm^2/hill) at peak growth stage (100 DAT) and number of matured fruits per hill as influenced by number of rows of barrier/ barrier species (pooled data of 2005-06 and 2006-07)

Treatment	**Leaf area (cm^2/hill)**		**Number of matured fruits per hill**	
No. of rows	**windward**	**leeword**	**windward**	**leeward**
Barrier crops				
3 rows	1077.0^c	1322.0^b	37.0^b	38.0^c
6 rows	1205.0^b	1579.0^a	45.0^a	44.0^b
9 rows	1318.0^a	1692.0^a	47.0^a	47.0^a
CD at 5%	72.7	116.6	3.19	2.70
Barrier species				
Grain sorghum	1220.0^b	1644.0^a	45.0^b	45.0^a
Grain maize	1140.0^b	1352.0^b	40.0^c	41.0^b
Fodder sorghum	1304.0^a	1762.0^a	49.0^a	47.0^a
Fodder maize	1136.0^b	1366.0^b	39.0^c	38.0^b
CD at 5%	84.0	134.6	3.68	3.10

Number of matured fruits per hill were higher with number of rows of barrier (44.0 and 47.0 fruits per hill in leeward side and 45 and 47 fruits /hill in the wind ward side with 6 and 9 rows for barrier respectively) Chilli with fodder sorghum and grain sorghum barriers produced higher number of fruits per hill with least LCI (Sivaprasad, 2008).

Table 5: dry fruit yield (kg/ha) and net returns (Rs/ha) as influenced by number of rows of barrier and barrier species

Treatments	**Dry fruit yield (kg/ha)**		**Thrips population/leaf**			
Number of rows of barrier crops	**Wind ward**	**Leeward**	**Windward**		**Leeward**	
			30 DAT	60 DAT	30 DAT	60 DAT
3 rows	990	1079	1.13 (1.46)^a	0.60 (1.26)^a	0.93 (1.39)^a	0.55 (1.24)^a

6 rows	1084	1189	0.83(1.35) [b]	0.46 (1.21) [b]	0.75 (1.32) [b]	0.36 (1.17) [b]
9 rows	1146	1244	0.71 (1.31) [b]	0.42 (1.19)	0.67 (1.29) [b]	0.32 (1.15) [b]
CD at 5%	64.8	57.1	0.05	0.03	0.04	0.03
Barrier Species						
Grain Sorghum	1137	1255	0.85 (1.36) [bc]	0.46 (1.21) [b]	0.71 (1.31)[b]	0.33 (1.16)[a]
Grain Maize	1008	1104	0.94 (1.39) [ab]	0.56 (1.25) [a]	0.88 (1.37) [a]	0.44 (1.20) [a]
Fodder Sorghum	1174	1225	0.71 (1.31) [c]	0.35 (1.16) [c]	0.60 (1.26)[b]	0.34 (1.16)[b]
Fodder Maize	975	1098	1.05 (1.43) [a]	0.56 (1.25) [a]	0.93 (1.39) [a]	0.52 (1.23) [a]
CD at 5%	130	65.9	0.05	0.04	0.04	0.03

Figures in the parenthesis are transformed values

Dry chilli yield was significantly higher with 6 and 9 barrier rows as compared to six rows Chilli with fodder and grain sorghum as barriers recorded significantly higher dry fruit yield compared to chilli with both grain and fodder types of maize as barriers crops. Nine and six rows of barriers recorded minimum thrips population at 30, 60, and 90 days after transplanting. Among the barrier species thrips population with fodder and grain sorghum as barriers were the lowest on either side of the barrier. Similarly, mite populations with nine and six rows barrier crop was lower compared to the 3 rows. Fodder sorghum and grain sorghum barrier crops noticed significantly lower mite population compared to fodder and grain maize as a barrier crop (Shivaprasad, 2008).

In Chilli + Jayadhar cotton intercropping system the non-chemical approach of pest management includes, maize as a barrier crop for sucking pest and mariegold as trap crop for management of fruit borers. Further, *Verticillium lacanii* @ 2 g/l. NSKE (5%) sulphur @ 3g/l, will help in management of sucking pests and mites in chilli. *Ha*NPV @ 250 LE/ha, *N.rileyi* @ 2 g/l and bio-digester (10%) spray were effective management of fruit borer. There was no significant difference between in all the three systems in the management of pests. In general in organic system predatory mites spiders and other natural enemy population was more (Babalad, 2011).

Table 6. *Nomuraea rileyi* affected larvae, natural enemy population, fruit damage and leaf curl Index in Chilli

Treatment	*N. rileyi* affected larvae/5 plant	Coccinellids/5 plant	Damaged fruits/plant	Fruit damage (%)	Leaf curl Index
Organic	2.00	6.67	1.00	5.19	1.97
Integrated	1.67	2.67	1.33	7.33	1.93
Inorganic	0.67	1.00	1.67	11.29	1.66
SEm±	0.38	0.69	0.24	1.52	0.01
LSD(0.05)	NS	2.72	NS	NS	NS

Fruit borers such as *H. armigera* and *S. litura* pose problems in some tracts where chilli is grown in large area. Releases of egg parasitoid such as *T. chilonis* or *T. pretiosum* are recommended for effective management of *H. armigera*. Even *Ha*NPV or *Sl*NPV may be useful for the control of respective borers in this crop. Leaf curl index of chilli was significantly reduced with the spray of garlic chilli kerosene extract (GCK @ 0.5%) + Nimbecidine against both thrips (0.4 LCI) and mites (0.8 LCI) next best treatment was found to be turmeric + cow urine 12.5% and GCK (1.0%) alone (Mallapur and

Lingappa, 2005). The highest pod yield was obtained in GCK + Nimbicidine treatment (10.6 q/ha) followed by insecticide application (9.0 q/ha) and GCK (1%) alone (9.5 q/ha).

Table 7. Management of chilli pests through indigenous materials (pooled data of years)

Sl. No.	Treatments	Leaf curl index	Dr pod yield (kg/ha)
1	Nimbicidin (0.5%)	0.7	910
2	GCK (0.5%)	0.6	900
3	GCK (1%)	0.5	950
4	GCK (0.5%) + Nimbicidine (0.25%)	0.4	1060
5	Termic + Cow urine (12.5%)	0.5	900
6	Parthenium	0.7	820
7	Cow urine	0.80	810
8	Re. Insecticides	0.60	990
9	Untreated check	1.20	680

(Mallapur and Lingappa, 2005)

Thrips, (*Scirtothrips dorsalis)* is also considered a major problem in Chilli on this pest. Anthacorid predators *Orius tantillus* and *O. maxidentus* were reported besides very few parasitoids. But exploitation of these biocontrol agents was not fully explored. Biology, feeding potential and limited scale exploitation of *O. tantillus* against thrips on capsicum under protected conditions, etc. were carried out. A release rate of 2 predatory nymphs of *O. tantillus* was found on par with 3,5,10 predators per plant in controlling the thrips on capsicum under polyhouse conditions (Krishnamoorthy, 2009). The thrips can also be controlled effectively using insect pathogen such as *M. anisopliae* @ 1 x 10^9 spores/ml.

Organic plant protection package for pest and disease management for chilli at Rajasthan comprising of setting up of pheromone traps, spray with cowurine (10%) + Neem oil (1%), spray of garlic extract (2%) + sprays of cow urine + garlic extracts (2%) + Azadirachtin (3ml/l) in requence were found effective (Jangir *et al.,* 2011).

The package of practices for organic chilli production

Based on package of practices of conventionchilli cultivation in label at UAS, Dharwad and the trials carried out under network project on organic farming have been developed and are as follows.

Variety: Byadagi Kaddi & Byadagi Dabbi, Devanur local, varieties maturing in 180-200 days are grown for dry chilli purpose. Besides, large number of varieties and local types are grown in major chilli growing areas.

Seeds: Successful production of chilli is basically conditioned by quality of the seeds sown. The prime quality attributed of good seeds being, genetically true to type, uniform, maximum germinability and vigor. Seeds should be collected from healthy plants and healthy fruits. It is better if first or second picked fruits are used for extraction of seeds. It is better to store fruits for seed purpose than the extracted seeds. The fruits harvested at physiological maturity stages (reddening) of seeds have better germination and have longevity of the seed.

Nursery raising: Well drained land near the vicinity of water source is usually selected for raising seedlings. Land is ploughed and harrowed to fine tilth. The nursery kept is raised for green level with one meter wide and 7-5 meter long. 15 such beds are required to grow seedlings required for 1 hectare area. Many farmers are preparing chilli seedlings in flat beds in years of heavy rainfall the seedlings will succumb to damping off due to water stagnation in the beds. Hence, it is advisable to go for raised seed beds rather than flat bed method. Adequate organic manures, 30 kg FYM and 10 kg Vermicompost for each bed are added at the time of preparation of beds. The microbial consortia containing *Azospirillum*, PSB, *Trichoderma* and mycorrhiza have to the applied along with organic manure to the bed. The seeds are sown on the beds in line opened at five centimeter apart. The beds are covered with straw or tur stalks. After germination the cover is removed and the beds are watered daily. The seedlings will be ready in 35-40 days. In the nursery, spray the seedlings with neem seed kernel extract verticillum and botanicals prepared to manage the sucking insects and also defoliators. It is better if the nursery is covered with net to avoid the sucking pests which are vectors for the viruses causing murda disease complex.

Inputs required per ha

a) Seeds	3 kg
b) Organic manures	
FYM	5.6 t
Vermicompost	4.0 t
Green leaf manure	5.0 t
Neem cake	2.5q
c) Bio-fertilizers	
Azospirillum	1 kg
PSB	1 kg
d) Bio-pesticide	
Trichoderma harzianum	500 g
Verticillum lecani	1 kg
Pseeudomonas flowrescence	1 kg
Neem seed kernel extract 5%	

Sowing: Direct sowing is practiced under rainfed combinations. Chilli seeds are drill sown directly in to the main field at 90cm or 60cm row spacing. The seed rate of 2.5 to 3.0 kg per ha are used. After 25 to 30 days the seedlings could be thinned out by maintaining an intra – row spacing of 20 – 30 cm.

Manuring and planting to main field: Apply all the organic manures FYM 5.6 t/ha, and green leaf manure 5 t/ha 15 days before sowing under rainfed condition. Seedlings are planted at row spacing of 90 cm X 90 cm in black soils and 60 cm X 60 cm in red soils during June and July cris by agency cross lines with the help of marker hills are formed depending upon the spacing (2 t/ha). For transplanting, 40 to 45 days seedlings are used and these are dipped in slurry prepared from dung, Azosprillum, PSB and Trichoderma in water. At each hill small pits are opened and mainly organic manures half of the recommended vermicompost (2t/ha) along with 250 kg of neem cake are applied. Micronutrients like zinc sulphate and copper sulphate @ 10 kg/per ha with vermicompost applied at the time planting is beneficial. Before planting apply a small quantity of water to each hill. The roots of the seedlings are pushed in to the moist soil and seedlings are pressed for quick establishment. The remaining 2 tonnes/ha of vermicompost was applied at 25 to 30 days after planting or sowing and intercultivate field. Cow urine spray at the rate of 10% at 30, 45 and 60 days after transplanting or sowing and Panchagavvya @ 3% spray at 60 and 75 DAS or days after planting as a source of nutrient and growth promoter helps to enhance growth, increase flower retention and growth of fruits.

Weed Management: Intercultivation at 30, 45 and 60 DAS and hand weeding at 30 and 50 DAS will help to manage the weeds. After last intercultivation mulching in between rows helps to conserve the moisture and future emergence of weeds.

Chilli based intercropping: Chilli crop is generally grown as a mixed crop under rainfed conditions. However, under irrigated conditions it is grown as an entire crop. Mixed cropping of chilli with onion, garlic, corrinderand Jayadhar cotton is very popular among the farming community in Karnataka and Maharashtra. Mixed cropping in chilli is generally practiced with ripe dry chilli crop rather than with green chilli. In the transitional tracts of Dharwad and Haveri and dry tract of Gadag and Koppal in Karnataka intercropping of onion, garlic, corrinder and cotton with chilli is a well established and remunerative cropping system followed on a large scale. In sandy soils, horsegram and castor crop are raised as mixed crop with chilli. It is also observed that the yield of chilli as a mixed crop is not going to be substantially reduced as compared to entire crop of chilli under rainfed conditions and so also the yield of companion cotton crop. Moreover, the peak period of growth of the companion crops and their rooting pattern are different. As a result, there is not much competition for Sun light, space, nutrients and soil moisture as root ramifications of mixed crops are different so also period of growth of crops.

Plant protection measures: Thrips, mites, aphids, root grubs and pod borers are the major pests in chilli, Fruit rot caused by *Colletotrichum capsici* is the major disease of chilli. Based on the field trails carried out on "Integrated organic plant protection in chilli" under Network Project on Organic Farming at Main Agricultural Research Station, Dharwad, the following plant protection model was found effective in management of pest complex in chilli and it was produced higher yield. These practices have been followed with integrated organic nutrition which included organic manure, green manure, bio-fertilizers and liquid organic manure like cow urine and jeevamruth.

1. Grow 6 rows of fodder or grain sorghum or as barrier crop to manage the sucking pests in chilli. Restricted installation of pheromone traps in the field @ 5 per ha helps to monitor the adult moths.
2. One row of marigold at every 10 rows of chilli as a trap crop for management of fruit borer and nematodes.
3. *Verticillium lecani* + Econeem (Neem powder) applied after 30 DAP or sowing @ 2g/l of water and 5 g/lit of neem powder to manage sucking pest. Spray cowurine 10% *Pseudomonas fluoresence* @ 5 g/l and trichoderma @28/l of water can be sprayed to manage anthrachose and other disease in chilli.
4. Panchagavya @ 5%+ Neem seed kernel extract @ 5% applied after 80 DAP or sowing in order to control sucking pests and murda complex.
5. Neem seed kernel extract @ 5% +indigenous botanical pesticide @ 10% applied after 60 and 80 DAP two sprays insequence in order to control sucking pests.
6. Release of Trichoderma chilons @ 50,000/ha per release two times for management of Helicoverpa.
7. *Spray HaNPV* 250 LE per ha and *GCA* extract 2 % in order to control Helicoverpa fruit borer after 100 and 120 DAP respectively other noticing moths in pheromone traps.

Harvesting tag and drying: Chilli is harvested at red ripe stage in two or three pickings. Retaining ripe fruits for long period cause colour fading and quality detraction. The chillies are sun dried to moisture content of 8-10% to avoid microbial activity and alotoxin production. The fruits are dried on concreate floor on tourplencs, they are frequently turned /stirred and covered with polythene sheets during night to avoid due deposition and fading of colours. The modern air blown drier can be used to avoid contamination and dust which is common in conventional drying. In 18-24 hrs mtrs the fruits are dried in this at 44^0-46^0 c. It avoid drying operation for 10-15 days and also imparts deep red colour and texture to fruits.

Yield: Productivity depends on soil and climate conditions and growing situations. Under rainfed conditions 10-12 quintals /ha dry chilli yield and 22-25 quintals /ha under irrigated situations can be obtained.

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Production systems and health management in ginger and turmeric

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Turmeric and ginger are rhizomatous crops belongs to the family Zingiberaceae and cultivated in almost all the states of India. Ginger cultivated in an area of 0.12 m. ha with a production of 0.63 m. tonnes and important ginger growing states are Kerala, Karnataka, Sikkim, Meghalaya, Himachal Pradesh, Gujarat, Orissa, West Bengal, Uttaranchal, Assam, Arunachal Pradesh, Mizoram, and other Northeastern states. India contributes around 30.27% to the world production of ginger. Turmeric is grown in 0.16 million ha with a production of 0.71 million tonnes. An estimate indicates around 80% of world production is from India. Important turmeric growing states are Andhra Pradesh, Karnataka, Orissa, Tamil Nadu, West Bengal, Gujarat, Maharashtra and North Eastern states. Trends in area and production of these crops are in the increasing order. However, price fluctuations are common and it determines extend of cultivation. India also imports ginger and turmeric. These two spices are annual crops with duration of 8 to 10 months suitable for different cropping systems.

Production systems

Turmeric and ginger are cultivated in tropical and subtropical climate. Turmeric is better adopted than ginger and both are grown in wider range of soil types. They are grown as rainfed where rainfall is high and distributed well for about five to seven months. In states like Kerala, North Eastern states, partly in Karnataka, Orissa, West Bengal, Himachal Pradesh crop is cultivated as rainfed. In less rainfall areas grown with irrigation and sources of irrigation may vary i.e., well, dam, tank, river etc.,. The states like Tamil Nadu, Andhra Pradesh, Maharashtra, partly in Orissa and West Bengal these are cultivated with irrigation. Number of irrigations varies with soil type and climate of the location. The number of irrigation varied with soil type, 15 to 20 irrigations are given for clayey soils and about 40 for sandy loams. Generally, rainfed system is practiced in hilly areas and adjoining plains and irrigated production mostly in plains and low lands. Mulching is an important operation in rainfed production, whereas, it is not generally followed in irrigated system as it interfere with irrigation water flow and other operations. Mulching in rainfed system have advantage of preventing soil splash during heavy rain and regulates temperature besides enriching soil fertility and suppressing weeds. De-haulming just a week or two before harvest generally is practiced for turmeric in irrigated condition, but it is not practiced in rainfed system of production where crop naturally dry due to lack of moisture at the end of the season. De-haulming would facilitate the maturity and easy harvesting.

Varieties

Ginger and turmeric crops are vegetative propagated. There are several locations specific traditional varieties are available in each state. In turmeric varieties with different duration (short -7 months, medium, 8 months, long 9 months and above) are available, whereas, in ginger there is no such distinction exists. It is essential to develop short duration types for fitting into different cropping system and coping with climate adversity. India has rich germplasam stocks in these spices and screening them for drought, cold and soil salinity and identification tolerant types is a need of the hour.

Tillage

Ginger and turmeric economic part is a rhizome that develops below ground. Hence, providing ideal soil environment is essential. Soil should offer only minimum resistance for rhizome development, so that good shaped rhizome can be harvested. However, there is no study on soil compactness on rhizome growth and development. Range of soil requires different kind of treatment. Rainfed and irrigated systems requires different type of land preparation. Ploughing six times have practiced to bring the soils to a fine tilth. Some times, 12 to 13 ploughings are given and then leveled and water channels are formed to irrigate the crop. However, there is no added advantage in ploughing the land over the minimum requirement of three to five times. Solarization of beds for 40 days by using transparent polythene sheets with *Trichoderma* application are recommended for the areas prone to rhizome rot and nematode. Earlier country plough was used, nowadays most of the farmers uses tractors for land preparation. In slope and fragmented lands mechanization may not be possible, only option is manual preparation. Machines for planting and other intercultural operations are needed to be developed to overcome labour problems.

Planting material

In both the crops rhizomes are used as a seed. In turmeric, there are mainly two types of rhizome viz., mother and fingers. Fingers further classified as primary, secondary or tertiary. In general, planting mother rhizome gives better yield. Mother rhizome alone may not sufficient to cover large area, hence, in addition to mothers; primary fingers are also used as seed. Some farmers plant mother and primary fingers separately. In the event of deficit in seed, farmers may split mother rhizome and use. In case of ginger, it is difficult to distinguish rhizomes. Normally a piece of rhizome is used. An ideal seed size is 25 to 30 g. However, size may vary with rhizome boldness. Farmers use even bigger sized rhizome. Use of bigger rhizome may increase the yield per plant, but multiplication ratio would be reduced. Around 2000kg seed is required per ha. Use of micro rhizome as a seed also successfully demonstrated. Aeroponics and container cultivations are becoming popular for seed production. The present seed requirement in India is 0.23 and a 0.32 m tonne in ginger and turmeric, and it is for 2025 is 0.31 and 0.44 m tonnes, respectively.

Seed treatment and planting

Planting healthy seed is very important for better crop and yield. Seed treatment is advantages in reducing pest and pathogen infestation. Seed is treated with pesticides or hot water treatment. Seed is planted in ridges and furrows, raised beds, or flat beds. Depth of planting generally, 5cm is ideal. Spacing varies with variety, soil type, irrigation source etc. Normally, 30 x 15 cm spacing or 30 x 20 cm spacing is adopted. Crop season commences from April to May and ends in December – January; it may vary with location and duration of varieties. Water availability determines the time of planting. Transplanting has been reported both in ginger and turmeric; however, it is not commonly seen among farmers. In rainfed, after planting mulch is applied to 5 to 10 cm thickness. The materials used vary with location and availability. Mixed green leaf mulch was found better in enhancing the yield.

Nutrition

Plant health is achieved by adequate nutrition and irrigation, in addition to plant protection. Adequate amounts of nitrogen, potassium, calcium, magnesium, phosphorus, sulphur, chlorine, iron, boron, manganese, zinc, copper and molybdenum are essential for healthy growth of the crop and higher yield. The first six are needed in relatively large amounts and are referred as major elements or macronutrients. The remaining elements are needed in much smaller amounts and are known as trace elements or micronutrients.

The need for organic nutrition has been emphasized by many workers; soil organic matter has positive correlation with yield. The quantity of organics applied may vary with availability of materials and generally it varies between 5-30 t ha^{-1}. Organics are mostly applied as basal and in certain places it is also applied after the emergence of crop as a mulch. Fertilizer recommendation varies with variety, soil type and climate. A fertilizer dose of 36-225: 20-115: 48-200 N, P_2O_5, K_2O kg ha^{-1} has been adopted for ginger in different states in India. In case of turmeric, the nitrogen recommendation varied between 60 and 200 kg ha^{-1}; phosphorous dose between 50 and 125 kg ha^{-1} and potash between 50 and 250 kg ha^{-1}. The uptake of nutrients increased with dry matter production. The maximum uptake was observed in active vegetative growth phase. Higher uptake of K upto third, N upto fourth and P upto fifth months of development was observed with subsequent decrease in their uptake. Use of mother rhizomes enhances the uptake of N, P and K as compared to primary or secondary rhizomes for planting. Micronutrients becoming integral part of production and it should be applied based on soil analysis and deficiency level. Each state have their own recommendations based on the local climate and soil.

Green manure crops are raised in areas where manure is in short supply. Sun-hemp is usually sown for the purpose. Green leaves are used for mulching turmeric and ginger fields in some production centers. The bulky organic manures are supplemented in certain cases with groundnut cake or castor cake. These are broadcasted over the field at the time of the first weeding and covered by ploughing in between the rows, or by hand hoeing. These are also applied along the rows or near the base of individual plants. Bio-fertilizers also used to supplement the nutrient requirement.

Irrigation

Irrigation is essentially practiced in low rainfall areas, number of irrigation vary with climate and soil type. Most of the places conventional irrigation is followed. However, there is a greater awareness among farmers on pressurized irrigation systems. Farmers adopt drip or sprinkler irrigation to improve the efficiency and save the water resource. Fertigation techniques are also practiced by some progressive farmers. Ginger and turmeric are planted as row crops, hence, drip system is better practiced in these crops. Sprinklers are also adopted for these crops. Water requirement is around 1000 to 1500mm and the critical stages for irrigation are germination stage, rhizome initiation stage (90 days after planting) and rhizome development stage (135 days after planting). The first irrigation starts immediately after planting and subsequent irrigations are given at intervals of 10 days and it may vary.

Weed management and earthing up

Weed management is one of the important intercultural operations. Weeds are problem during initial stages until crop covers the land area completely. Crops take about 15 to 30 days for emerge out. Weed control at early vegetative phase is must and use of herbicide promoted due to non-availability of labour. Weed flora varies with location; generally, two to three weeding are practiced depending upon weed intensity. Inter-cultivations such as weeding, side dressing and earthing up (hilling) are followed simultaneously. Under rainfed system second and third mulching also combined with these operations. Manual weeding by digging helps in soil aeration and facilitates earthing up. Earthing up is an important operation that enables better rhizome expansion and development. Due to lack of labour availability, farmers use pre-emergence herbicide to check weeds and even avoiding earthing up. The critical period for weed competition is 70 to 160 DAP.

Shade and cropping system

Ginger and turmeric are amenable for many cropping system. It is grown as understory crop under tall plantation / fruit crops / agro-forestry systems. Besides these, many crops such as cereals, pulses, vegetables can be inter/mixed cropped with ginger and turmeric. Ginger + Maize, Turmeric + Red gram, Turmeric + Small Onion are few examples. The choice of the system depends on farmers need. It is better to provide nutrition to met the both the crops requirement in the system. Intercropping is a better option where weather aberrations or pest and diseases problem are common. Crop rotation is essential to avoid yield reduction and reduce the crop associated pest and diseases. Soil health is achieved by crop rotation and by adopting turn around period. High shade should be avoided, 25% to 50% shade is ideal and it varies with location.

Harvest

Ginger is ready for harvest in about 8 months after planting when the leaves turn yellow, and start drying up gradually. The clumps are lifted carefully with a spade or digging fork and the rhizomes are separated from the dried up leaves, roots and adhering soil. For preparing vegetable ginger, harvesting is done from sixth month onwards. The rhizomes are thoroughly washed in water and sun-dried for a day.

In turmeric under irrigated situation, irrigation is stopped a month before harvest and dehaulming is practiced one or two weeks before harvest, it facilitates maturity and easy harvest. The leaves harvested are used as a fuel for boiling turmeric rhizomes in some areas. Harvesting is done manually on contract basis, nowadays mechanical harvesters are available. Power tiller based and tractor drawn turmeric harvester is available for labour saving and efficient harvest. In India, normally harvesting is done from January to April, depending upon the locations.

Seed storage

Seed health is very important, unless seed is stored under ideal condition, it would be susceptible to seed born pest and diseases. Improper storage leads to rotting, shrivelling, dehydration and sprouting. Farmers follow location specific seed storage methods. Normally storing under shade by covering the rhizome with dried leaves during off-season is common. Maintaining a storage temperature of 22-25°C is ideal, temperature higher than 28°C in the long run make the buds thin and weak. If the storage humidity is too low, rhizome epidermis may also loose water and wrinkle and the sprouting speed and bud quality may be affected. The stored rhizomes are examined monthly intervals and rotten rhizomes removed to keep pathogen free.

Conclusions

Ginger and turmeric are important spice crops of India and their demands are increasing for diversified uses. This demand could be met by adopting appropriate location specific production systems and designing suitable cropping system. Mechanization in planting, intercultural operation and harvesting is an inevitable component in future crop production of these crops. Developing early maturing varieties to cope with climate change, screening germplasam for drought and for different production systems also need to be addressed. Nutrition scheduling has to be evolved for changing soil environment and crop varietal requirement. Community approach for seed production and seed storage is essential for sustained seed health.

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Production system and health management in black pepper

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Black pepper is grown in 26 countries with a world production of 369587 MT from 467708 ha (FAOSTAT 2004). International markets receive pepper from Vietnam, Brazil, Indonesia, India, Malaysia and Sri Lanka and India contributes about 10% for the world market. The countries like India and Thailand produces mainly black pepper where other countries produce both black and white pepper. India with more than 40% share of the world area under pepper, contributes about 23% of the total production of pepper in the world. In India, pepper is cultivated in an area of 1,95,920 ha with a production of 51,020 MT (2009-10) with a productivity of 260 kg ha^{-1}, with inter annual variations in area, production and yield over the years. Cultivation is mainly confined to states like Kerala, Karnataka and Tamil Nadu. However, it is cultivated to a lesser extent in Andaman and Nicobar Islands, Pondichery, Maharashtra, Andhra Pradesh, Orissa, Goa, West Bengal and North Eastern States. The quantity exported varies over the year, during 2009-10, our export estimate was 19,750 MT with a value of ` 313.9 crores and we export to more than fifty countries. Sixteen black pepper varieties were released for cultivation by IISR and Kerala Agricultural University that had a great impact in increasing the production and productivity of black pepper in the country.

Climate

Black pepper grows successfully between 20° N and 20° S of Equator and from sea level up to 1500 m above mean sea level. As a crop of humid tropics, it requires 2000-3000 mm rainfall with a relative humidity of 60 – 95% with a little variation in day length throughout the year. The black pepper growing tracts in India receives bimodal rains from South West (June to September) and North-East monsoons (October-November) with 120 to 135 rainy days and the rainfall distribution is more important than its total quantum for yield. Long spells of dry periods are harmful. The crop survives at temperature between 10°–40°C. Optimum soil temperature for root growth is 26°–28°C. Among weather variables, mean maximum temperature in March first fortnight and June second fortnight, total rainfall during March second fortnight and September second fortnight (RAIN > TMIN > TMAX), were found to be significantly correlated with the pepper yield (Kandiannan *et al*., 2010).

Soil

Black pepper plantations are established on a wide variety of soils, their texture varying from sandy loam to clayey loam. Well-drained deep loamy soil, rich in organic matter with good water holding capacity and pH ranging from 5 to 6 are adequate for growth. Liming is a recommended practice to neutralize the soils having pH less than 5. The major soils in black pepper growing tracts of India can be broadly classified into mollisols (forest loam), alfisols (red loam), oxisols (laterite), entisols (alluvium) and alfisols (red loam) (Sadanandanan, 2000). Soils of high yielding black pepper gardens are generally sandy to loam textured with near neutral pH, high in exchangeable bases, organic carbon and micronutrients, especially zinc.

Planting

Black pepper grows well in plain or steep sloppy or levelled lands with good drainage/ moisture conservation measures such as contour planting and terracing. Pepper is planted usually on the northern slopes to avoid the scorching sun, in pits of 50 cm^3, 30 cm away from the support trees. For a mono crop of pepper, spacing of 3 x 3 m, accommodating about 1100 supports per ha is recommended. Under mixed cropping system with coconut/ arecanut or coffee based systems the population may vary from 150-500 per ha. The planting pits are filled with top soil, FYM or well decomposed compost (2-5 kg) and 150 g rock phosphate and two rooted cuttings are planted in each pit immediately after the onset of rains. Application of coconut husk mulch in basins around plants is beneficial for the successful field establishment of pepper in low rainfall areas.

Standards

Providing ideal supports/ standards is important for successful establishment of black pepper as vine is going to be productive for more than 15 years. Even though non-living standards are more commonly used in Malaysia, Brazil and Indonesia, owing to the high capital investment they are not very popular in India. In India, varieties of trees are used as living standards for black pepper cultivation *viz*., *Erythrina indica*, *Garuga pinnata, Ailanthus* sp, *Gliricidia sepium, Leucaena leucocephala* etc. In high altitude areas under cardamom and coffee plantations, dadap, silveroak and various forest trees that provide shade are successfully used as standard for pepper. In homesteads gardens in Kerala, black pepper is usually trained on arecanut and coconut and also on mango, jack, etc.

Living standards should be planted 3-4 years in advance so as to attain sufficient height at the time of planting of black pepper. In case of *Gliricidia sepium* or *Garuga pinnata* as shade trees, pepper cuttings are also planted along with the sprouted stems with the receipt of first rain in May-June. The native standards such as *Thespesea populnea, Leucana leucocephala*, *Erythrina lithosperma* (dadaps), and *Moringa olefera* (perennial moringa) are also used as standards for training black pepper. As and when the vines are growing, it is tied with support trees for its proper upward growth. To induce more root system and more leader shoots a practice called lowering is done, where leaves are removed when vines attain a height of one meter and $3/4^{th}$ of the basal portion is buried around the standard and covered with good top soil. Moderate pruning of standard is recommended during the beginning of rainy season by retaining one or two twigs at top of the trees to allow more sunlight into the pepper canopy. This will also help in bringing down the pollu beetle infestation. For easy harvesting, height of the standard and that of the vine may be restricted. When pepper is trailed on coconut or arecanut palms, height may be restricted to 5 meters for easy harvest.

Irrigation

Pepper as a crop of humid tropics, is mainly grown in rainfed and also as irrigated crop in low rainfall areas. Moisture stress is one of the most serious constraints affecting different sensitive periods for black pepper like flowering, setting, spiking and spike elongation, thereby the productivity. As first 16 weeks after summer is considered to be critical period for shoot growth, flower bud differentiation, spike emergence, flower opening and fertilization, berry formation and development, rainfall received during second half of May (responsible for spike formation) and June is crucial for proper setting of berries. Spike development ceases if there is a prolonged dry spell immediately after good summer showers. Spike shedding is seen when the pre-monsoon showers are delayed and flowering and spiking occur during June-July. These spikes predominantly produce female flowers instead of bisexual flowers and heavy spike shedding may occur due to lack of pollination. Irrigation of vines from second fortnight of March coupled with prophylactic spraying with Bordeaux mixture 1% or carbendazim 0.2% reduces the intensity of spike shedding.

The feeder roots of black pepper is distributed in the top 50 - 60 cm depth at 30 cm radius from the base of the vine and therefore sensitive to moisture stress. Basin irrigation of vines @ 100 litres per vine (hose irrigation) once a week during summer is recommended. In case drip irrigation is adopted, water @7 L per day may be given from October to May. Basal irrigation with 50 L of water during March - May and shade regulation in April helps in early initiation of spike and good setting (Gowda *et al* 2008).

Mulching

Mulching conserves moisture, regulates temperature, suppresses weed growth, enhances microbial activity and improves soil fertility. Mulching around the basins of black pepper vines with green leaves @10 kg /vine to a radius of one meter is required at the end of North east monsoon. Cover crops like *Calapagonium mucunoides, Desmodium trifolium* are grown in black pepper plantations for smothering the weeds, enhancing growth and yield.

Cropping system

Black pepper is well adapted as an under / mixed / inter crop with plantation crops. Pepper is intercropped with coffee, arecanut and coconut. Ginger, turmeric, coffee, banana, pulses like red gram, vegetables, flowers, fodders, tubers, medicinals and other annuals are intercropped with pepper. Among the released varieties Sreekara, Subhakara, Panniyur 2, Panniyur 5 are shade tolerant and suitable for mixed cropping under coconut. Panniyur 1, Panniyur 3 and Panniyur 5 are the most suitable cultivars for coffee-based cropping system in the hill zones. Crops such as greater yam, amorphophallus, ginger, turmeric, coleus, hybrid napier grass, guinea grass and congo signal grass are suited for intercropping in juvenile black pepper garden (Thankamani *et al*., 2010). Black pepper intercropped with amorphophallus and black pepper + ginger systems yielded maximum net profit under station trials.

Light

The availability of light plays an important role in the black pepper productivity. Higher light availability during pre-flowering produces greater leaf area resulting in more productivity. The productivity of vines decreases with decreasing light interception from tip to bottom of vine. Shade regulation of tree standards is an important practice during rainy / cloudy weather to allow sufficient light for crop growth. Panniyur-1 gives higher yield than in other varieties under more light exposure (above 50000 lux). Under huge canopies, top portion of the vine receives more than 50% of the incident light; middle portion receives only 30-40% and base less than 30%.

Nutrition

A moist, well-drained soil rich in organic matter with good drainage, water holding capacity and essential plant nutrients is imperative for sustainable yield. The blanket *recommendations* for *fertilizers* across the growing areas without relevant soil and plant nutritional status may cause nutrient imbalance and deficiency of yield limiting nutrients. This is more important for black pepper, as it is a perennial crop and the utilization pattern could be unique. Site-specific management is suggested for refined fertilizer strategies like integrated nutrient management, for sustaining yield and the environment. Among the nutrients, uptake of N is highest followed by K and Ca and among micro nutrients iron uptake is the highest and the magnitude of the nutrient removal is in the order: N>K>Ca>Mg>P>S. A soil fertility survey carried out in the major pepper growing tracts in the states of Kerala and Karnataka indicated that 10% of the gardens surveyed were low (< 120 kg ha^{-1}), 31% medium (120-280 kg ha^{-1}) and 59% high (> 280 kg ha^{-1}) in available K status.

Different researchers have reported a removal of 130-250 kg N, 30-60 kg P_2O_5 and 225 – 330 kg K_2O ha^{-1} by pepper under different management conditions. Soil availability of secondary and micro nutrients are also of greater importance as the crop removes up to 50 and 35 kg of C and Mg, respectively and deficiency of zinc, molybdenum and boron may become yield limiting. Boron deficiency can be expected in coarse textured soils low in organic matter, especially in high rainfall areas. Application of lime (@ 500 g vine^{-1} in alternate years) not only corrects the pH of the soil, but also improves the Mo availability, yield and quality of pepper. Varying levels of nutrients were recommended based on the soil type and agro ecological conditions for sustaining the crop health.

Nutrient uptake by black pepper and fertilizer recommendations

Soil fertility	Nutrients removed	Dose recommendation (kg ha^{-1})
High fertility	N 34, P_2O_5 3.5, K_2O 32 (kg vine^{-1})	N 50, P_2O_5 50, K_2O 200
Low fertility	N 137, P_2O_5 61, K_2O 330 (kg ha^{-1})	N 140, P_2O_5 55, K_2O 270

Application of Zn @ 5mg kg^{-1} for potted bush pepper and Zn @ 6.2 kg ha^{-1} for field condition was optimum for increasing yield and improving the quality of black pepper and application of ½ prevailing package of practices + Zn is a risk free rational technology for better returns. Foliar spray is effective for the micronutrient application since only very small quantities of these elements are required. Black pepper responds well up to 0.9 kg ha^{-1} of Mo in soil or foliar spray of 0.1% sodium molybdate and 0.5% $ZnSO_4$ with increase in quality (Srinivasan et al., 2007).

Integrated nutrient management with annual application of NPK at the rate of 100:40:140 kg ha^{-1} and organics like FYM at the rate of 5.0 - 10 kg vine^{-1} enhanced the fertility of soils under black pepper. Inorganic nitrogen and phosphorus dose could be reduced by 50% by substituting with FYM. In addition, chicken manure/ vermicompost/ coir pith compost at the rate of 1-2 kg plant^{-1} can also be applied in combination with biofertilizers (Azospirillum, AMF, phosphobacteria). For balanced nutrient application based on the crop uptake, soil test based fertilizer recommendations for fixed yield targets has been standardized based on field trials at IISR. Based on this, yield levels up to 7.0, 8.7 and 9.7 kg/vine could be achieved under the targeted yields of 5, 7.5 and 10 kg/vine, with a mean deviation of +40.2%, +15.6% and -2.9%, respectively and through soil test based targeted nutrient supply 6.3-47.3% yield increase could also be realized as compared to the blanket fertilizer recommendation. The economic optimum in terms of profitable response for money invested is up to ` 1.60 vine$^{-1}$ for nitrogen, ` 2.60 vine^{-1} for P_2O_5 and ` 5.30 vine^{-1} for K_2O, in black pepper.

It is recommended to apply one third of the dose of nutrients during first year of planting, two third in the second year and full recommended dose is given from the third year. In order to increase the use efficiency and minimize leaching loss, split application of fertilizers is generally recommended as black pepper is raised as a rainfed crop in heavy rainfall areas. In India, the recommended dose of fertilizers is applied in two splits, the first in May-June with the onset of monsoon and the second split during August-September. Fertilizer is applied in ¾ circles around the vine or in alternating parallel bands on either side of the vine underneath the edge of the canopy where about 90% of the feeder root activity is found.

Organic production

For certified organic production of black pepper, at least 18 months the crop should be under organic management *ie* in the new plantations the first crop of pepper can be sold as organic, as the yielding starts from third year. To convert an existing plantation to organic, a conversion period of 36 months is set for the perennial crops. It is desirable that organic method of production is followed in the entire farm; but in the case of large extent of area, the transition can be done in a phased manner for which a conversion plan has to be prepared. When grown in a mixed cultivation system, it is essential that all the crops in the field are also subjected to organic methods of production. Black pepper as a best component crop in agri-horti and silvi-horti systems, recycling of farm waste can be effectively done when grown with coconut, arecanut, coffee, rubber etc.

For organic production, traditional varieties adapted to the local soil and climatic conditions that are resistant or tolerant to diseases, pests and nematode infection should be used. All crop residues and farm wastes like green loppings, crop residues, grasses, cow dung slurry, poultry droppings etc. available on the farm can be recycled through composting, including vermicomposting so that soil fertility is maintained at high level. No synthetic chemical fertilizers, pesticides or fungicides are allowed under organic system. Farmyard manure may be applied @ 5-10 kg/vine along with vermi/ leaf compost @ 2-5 kg/vine based on the age of the vine. Trials conducted through AICRP on spices at various locations revealed that sustainable yield up to 6.5 kg vine^{-1} could be achieved by application of FYM (10 kg) + rock phosphate (40g) + wood ash (2 kg) per vine along with *Azospirillum* on par to the conventional practice in nutrient supplementation. Phosphate rich organic manure (PROM), a value-added product by co-composting different organic wastes with high-grade rock phosphate can be used as a useful and effective source for P. Based on soil test, application of lime/dolomite, rock phosphate/ bone meal and wood ash may be done to get required quantity of phosphorus and potassium supplementation. Further, supplementation of oil cakes like neem cake (1 kg/vine), composted coir pith (2.5 kg/vine) or composted coffee pulp rich in potassium and suitable microbial cultures of *Azospirillum* and phosphate solubilizing bacteria will improve the fertility (Parthasarathy et al., 2008).

Use of biopesticides, biocontrol agents, cultural and phytosanitary measures for the management of insect pests and diseases forms the main strategy under organic system. Management of pollu beetle by Neemgold (0.6%) spray at 21 day intervals during July-October, shade regulation and that of scale insects by removing severely infected branches and spraying Neemgold (0.6%) or fish oil rosin (3%) are recommended. Application of biocontrol agents like *Trichoderma* or *Pseudomonas* multiplied in suitable carrier media such as coffee husk/ coir pith compost, well rotten cow dung or quality neem cake may be done regularly to keep the foot rot disease in check. To control fungal pollu and other foliar diseases spraying of Bordeaux mixture 1% may be done restricting the quantity to 8 kg copper per hectare per annum. Application of quality neem cake mentioned earlier along with the bioagent *Pochonia chlamydosporia* will be useful to check the nematode population and thereby slow decline disease.

Certification and labeling is usually done by an independent body to provide a guarantee that the production standards are met. Govt. of India has taken steps to have indigenous certification system to help small and marginal growers and to issue valid organic certificates through certifying agencies accredited by APEDA and Spices Board. The inspectors appointed by the certification agencies will carry out inspection of the farm operations through records maintained and by periodic site inspections. The grower has to document all the details with respect to Field map, Field history sheet, Activity register, Input record, Output record, Harvest record, Storage record, Pest control records, Movement record, Equipments cleaning record and Labelling records etc. Documentation of farm activities is must for acquiring certification especially when both conventional and organic crops are raised. Group certification programmes are also available for organized group of producers and processors with similar production systems located in geographical proximity.

Harvest

Black pepper is harvested 7-8 months after flowering at full maturity, during December –January in plains and January-April in the high ranges. The spikes are nipped of by hand and collected in bags when one or two berries in the spike turn red or yellow. If the berries are allowed to over ripe, there is heavy loss due to berry drop and damage by birds. Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity at harvest differs with different pepper products (Devasahayam et al., 2006).

Optimum maturity at harvest for pepper products

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

Future strategies

The main strategies for sustaining the black pepper should focus on

- Extending black pepper cultivation in non-traditional areas where climate is suitable and inter cropping is to be practiced to enhance the productivity
- Promoting adoption of biofertilizers, biocontrol agents, cover crops and ecofriendly inputs
- Developing decision support systems, data bases, prediction models and production strategies based on site specific nutrient applications and GIS & Bio informatics tools in pepper cultivation
- Increasing productivity of spices through replanting and rejuvenation of old gardens, good agricultural practices, INM and organic farming

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Plant health management in spice crops-An overview

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Poor plant health due to infestation by pests and pathogens is one of the major factors for the low productivity of major spice crops like black pepper (*Piper nigrum*), cardamom (*Elettaria cardamomum*), ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) in India. Intensive use of spice crop ecosystems to enhance productivity can also erode ecosystems affecting plant health. Hence adoption of sustainable pest management schedules which integrates a range of practices for economic control of pests and pathogens is important. The advances in plant health management of spice crops with particular reference to pests and pathogens, involving cultural and biological means, use of resistant varieties and plant products and need-based application of pesticides are highlighted in this overview.

BLACK PEPPER
Phytophthora foot rot

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

Management

The strategies recommended for the management of the disease include, raising black pepper cuttings in solarized soil fortified with bio-control agents, removal and destruction of dead vines along with the root system from the plantation, shade regulation with the receipt of pre-monsoon showers, and providing adequate drainage to prevent water logging especially during the monsoon season. In severely disease affected areas, IISR-Shakti which is resistant to the disease may be planted.

Antagonistic micro-organisms such as *Trichoderma harzianum* and *Pseudomonas fluorescens* may be applied around the base of the vine @ 50 g/ vine (10^8 cfu/g) at the onset of the monsoon during May-June and also during August-September. Addition of organic mulches and oil cakes in the basins improves the texture of the soil and enhances the growth of antagonistic micro-organisms. Prophylactic spraying with Bordeaux mixture 1% and drenching the basins with copper oxychloride 0.2% should also be undertaken with the onset of monsoon during May-June and also during August-September. Alternatively, the vines may be sprayed and drenched with potassium phosphonate 0.3% or metalaxyl-mancozeb 1.25 g/l during May-June and August-September. In case biocontrol agents are applied, drenching may be avoided.

Slow decline

Several plant parasitic nematodes are associated with black pepper in India among which root knot nematodes (*Meloidogyne* spp.), and burrowing nematode (*Radopholus similis*), are predominant. Slow decline is caused by the association of *M. incognita* and *R. similis* and also *P. capsici*. The affected vines exhibit foliar yellowing initially and with depletion of soil moisture during the post monsoon season, they show defoliation and die-back leading to loss of vigour, yield and finally death of the vine.

Plants infested with *M. incognita* exhibit inter veinal chlorosis and galling in roots. *R. similis* causes necrotic lesions on feeder roots which merge leading to disintegration of distal portion of the roots.

Management

Nematode management warrants a sustainable approach integrating several strategies. Use of nematode-free planting material, de-nematization of nursery mixture by solarization or fumigation with chemicals and fortification with biocontrol agents is important. In the field, uprooting and destruction of diseased vines along with root mass, and exclusion of nematode susceptible intercrops and supports trees can minimise nematode infestations. 'Pournami', *which* is resistant to *M. incognita* may be cultivated in root knot infested areas.

Application of antagonistic fungi, such as *Pochonia chlamydosporia* and *Pseudomonas fluorescens* around the base of the vine @ 50 g/ vine (10^8 cfu/g) at 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 phorate or carbofuran @ 0.1 g a.i./plant. In plantations, application of carbofuran or phorate @ 3 g a.i./vine during May-June and again in August-September may be undertaken when the infestation is severe.

***Pollu* beetle**

The *pollu* beetle (*Lanka ramakrishnae=Longitarsus nigripennis*) is the most destructive insect pest of black pepper in India especially in the plains and midlands. 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 hollow nature of the infested berries is termed as pollu in Malayalam). The pest infestation is higher during September-October especially in heavily shaded areas.

Management

Regulation of shade in the plantation by pruning branches of support and shade trees before the onset of the monsoon 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 are major insect pests of black pepper at higher altitudes. Among the scale insects recorded on the crop, the mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) are most common. 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 lateral branches wilt and dry resulting in vacant spaces in the canopy. The coconut scale infests mature leaves resulting in chlorotic patches and sometimes also infest 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

Spraying 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. Predatory beetles such as *Chilocorus* spp. and *Pseudoscymnus* spp., and hymenopterous parasitoids such as *Aphytis* sp. and *Encarsia* spp. are major natural enemies and are to be conserved. Natural products such as neem oil 0.3% or Neemgold 0.3% or fish oil rosin 3% are also effective for the management of scale insects during initial stages of infestation.

Emerging pests and diseases
Viral diseases

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

Adequate care should be taken to plant virus-free cuttings especially in new areas where the incidence of the disease is not observed in the field. Virus-free cuttings are to be identified and used for propagation under insect-proof conditions. 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 act as reservoirs for the virus need to be removed and destroyed. Regular monitoring of the nursery and field for insect vectors such as aphids and mealybugs is important which should be controlled with dimethoate 0.05%.

Anthracnose

Anthracnose caused by *Colletotrichum gloeosporiodes* is also known as *pollu* disease indicating the hollow nature of infected berries. The disease 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 formation of cross splitting on the berries. The disease when combined with predominance of female flowers, lack of pollination, heavy shade 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, prophylactic sprays with Bordeaux mixture 1% or carbendazim-mancozeb 0.1% and nutrition management are important for holistic management of the disease.

Root mealybugs

Colonies of root mealybugs (*Planococcus* spp.) are observed at the basal portion of the stem under the soil and on roots causing yellowing, wilting and mortality of vines. The pest infestation is more common at higher altitudes in and is more severe on vines affected with *Phytophthora* sp. and nematodes.

Root mealybugs can be managed by planting pest-free cuttings, removal of weeds in the interspaces of black pepper vines during summer and drenching chlorpyriphos 0.075% and also by undertaking management schedules against *Phytophthora* and nematodes.

CARDAMOM
Capsule rot

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

Management

Removal of dried leaves and leaf sheaths from basal portions of the plant and infected plant parts and mulch should be done prior to the onset of monsoon. Shade regulation and adequate drainage should also be provided to reduce the intensity of the disease. Bio-control agents such as *Trichoderma harzianum* (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% or potassium phosphonate 0.3% or alternate sprays of Bordeaux mixture 1% and metalaxyl-mancozeb 1.25 g/l are effective against the disease.

Rhizome rot

The disease is caused by the soil-borne fungi such as *Pythium vexans* and *Risoctonia solani* and is observed in nurseries and plantations during the monsoon season. In the nursery, the symptom is expressed as dark brown discoloration at the collar region of the seedling. The roots and rhizomes of affected plants rot and the leaves exhibit flaccidity which 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 later breaks off easily.

Management

Trashing and removal of infected plants and mulch should be done prior to the onset of monsoon. Shade regulation and adequate drainage should be provided to reduce the intensity of the disease. The rhizome rot resistant variety IISR-Avinash (RR1) may be cultivated in severely disease affected areas.

Bio-control agents such as *Trichoderma harzianum* (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. The plant basins are to be drenched with copper oxychloride 0.25% and Bordeaux mixture 1% sprayed on the plants during May-June and August-September. Alternatively, potassium phosphonate 0.3% or metalaxyl-mancozeb 1.25 g/l may be drenched and sprayed. In case bio-control agents are applied, drenching with copper oxychloride is to be avoided.

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. Often mosaic like mottling is also seen on the leaf sheath and young leaf shoots. In advanced stages the affected plants produce shorter and slender tillers with only a few short panicles The disease is transmitted through banana aphid *Pentalonia nigronervosa* f. *caladii*.

In plants affected with vein-clearing disease, the leaves show intra-veinal clearing, stunting, loosening of leaf sheath and shredding of leaves. Light green patches with shallow grooves are seen on immature capsules; cracking of fruits and partial sterility of seeds are other associated symptoms. The new leaves of affected plants get entangled in the older leaves and form hook like tiller The disease is transmitted through banana aphid *P. nigronervosa* f. *caladii.*

Management

Use of virus-free planting material is the primary requirement to check the spread of the disease. Removal of infected plants and weeds and alternate hosts which might act as reservoir for the virus and multiplication of the aphid should be undertaken regularly. Aphid vectors may be controlled by spraying botanicals. The *katte* resistant variety IISR Vijetha-1 may be cultivated in severely disease affected areas.

Root knot nematodes

Plants parasitic nematodes especially *M. incognita* and *M. javanica* cause considerable damage to feeder roots of cardamom in nurseries and plantations. Heavily infested mature plants exhibit stunting, reduced tillering, reduced leaf size, yellowing of foliage, delay in flowering, immature capsule drop, increased incidence of rhizome rot and reduction in yield. In the nursery nematode infestations is responsible for pre-emergence failure in primary seed beds and reduced production of standard seedlings in secondary nursery. Many weeds and shade trees like *Erythrina* spp. severe as hosts and help in build-up of population of nematodes in the field. Exposed areas and sandy soils favour higher multiplication of nematodes.

Management

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

Cardamom thrips

Cardamom thrips (*Sciothrips cardamomi*) is the most widespread and 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 also higher in thickly shaded areas in the plantation. A number of zingiberaceous plants growing in and around cardamom plantations serve as alternate host plants of the pest.

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 buildup of cardamom thrips population in the field. Pruning leaf sheaths during February-March before spraying operations also reduces the pest population and increase the efficacy of insecticides. Five to seven rounds of spraying of insecticides like chlorpyriphos 0.04%, fenthion 0.05%, phenthoate 0.05%, phosalone 0.07% or quinalphos 0.025%, during March, April, May, August and September are required for controlling the pest infestation.

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 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% , and collection and destruction of adults help in reducing the population of shoot and capsule borer in the field. Later, spraying fenthion 0.075% or quinalphos 0.075% twice, during January-February and September-October is to be undertaken for controlling the pest infestation. Conservation of natural enemies (hymenopterous parasitoids) such as, *Eriborus trocheanteratus*, *Xanthopimpla australis*, *Friona* sp. and *Agrypone* sp. help in reducing the pest infestation in the field.

Root grub

The root grub (*Basilepta fulvicorne*) is a serious 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 plants, especially seedlings, succumb to the pest attack. Seedlings damaged by the root grub are subsequently infected by secondary pathogens resulting in rotting. The females lay eggs around the root zone and the emerging grubs feed on the roots. 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 is effective in reducing the pest population in the field. The beetles emerge in large numbers especially during April-May after summer showers and congregate on cardamom plants and other trees around the plantations. Along with collection of adults, application of phorate 10 G @ 20–40 g/clump or chlorpyriphos 0.075% during May–June and September–October synchronizing with emergence of adults and egg laying periods is effective for the management of the pest. The entomogenous fungii *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 gloeosporides* 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 one or two rounds of sprays with Bordeaux mixture 1% or carbendazim-mancozeb 0.1%.

Whitefly

The cardamom whitefly (*Dialeurodes cardamomi*) is becoming serious in Kerala and Tamil Nadu especially during the dry summer seasons. The adults and nymphs are seen in colonies on the lower leaf surface and they suck the sap resulting in yellowing of leaves and affecting the vigour of plants. Setting up of yellow sticky traps to trap adults, conservation of natural enemies, and spraying neem oil (5%) or acephate 0.075% when the infestation is severe, is effective in controlling the pest.

Shoot fly

The larvae of shoot borer (*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 spraying with dimethoate or quinalphos (0.05% each) or application of carbofuran 3 G (20-25 kg/ha) are effective for the management of the pest.

GINGER AND TURMERIC
Soft rot (rhizome rot)

Soft rot or rhizome rot is the most destructive disease of ginger and turmeric which results in total loss of affected clumps. The disease is soil-borne and is caused by various species of *Pythium*. The fungus multiplies in the soil with buildup of soil moisture with the onset of the monsoon. 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 pseudostem, 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 of the plant and is 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, since stagnation of water predisposes the plant to infection. 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 x 1 m (10^8 cfu/g) should be applied at the time of planting and after 45 days. Addition of organic mulches and oil cakes in the beds improves the texture of the soil and enhances the growth of antagonistic microorganisms. Removal of affected clumps and drenching the affected and surrounding beds with copper oxychloride 0.2% or metalaxyl-mancozeb 500 ppm checks the spread of the disease.

Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* is also a soil and seed-borne disease occurring on ginger during the monsoon period. Water soaked spots appear at the collar region of the pseudostem which progresses upwards and downwards. The first conspicuous symptom is mild drooping and curling of leaf margins of the lower leaves which spread upwards. Yellowing starts from the lowermost leaves and gradually progresses to the upper leaves. In the advanced stage, the plants exhibit severe yellowing and wilting symptoms. The affected pseudostem and rhizome extrudes a milky ooze from the vascular strands when pressed gently and the rhizomes ultimately rot.

Management

Seed rhizomes are to be selected from disease-free gardens, and stored suitably. Selection of well drained soils for planting is important since stagnation of water predisposes the plant to infection. Fields used for growing potato, or any other solanaceous crops should be strictly 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 phytosanitation including use of contaminated tools and irrigation water should be avoided. The affected plants should be removed from the field and all the surrounding beds drenched with copper oxychloride 0.2%.

Nematodes

Root knot (*Meloidogyne* spp.), burrowing (*Radopholus 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. Characteristic root galls and lesions that lead to rotting are generally seen in roots. The infested rhizomes have brown, water soaked areas in the outer tissues. Nematode infestation also aggravates rhizome rot disease in ginger and turmeric.

Management

The nematodes 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. Addition of organic mulches and oil cakes in the beds improves the texture of the soil and enhances the growth of antagonistic microorganisms. In severe infestations application of carbofuran @ 3 kg ai / ha is advocated to reduce the population of nematodes in the field. In areas were 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 newly hatched larva feeds on the unopened leaf and later they bore into the shoots. 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% at monthly intervals during July–October is effective in controlling the pest infestation. The spraying should be initiated as soon as the first symptom of pest infestation is noticed in the field to achieve higher levels of control.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes of ginger and turmeric in the field (especially at later stages) and storage. The pest appears as encrustations on the rhizomes and feed on plant sap and they become shriveled and desiccated and fails to germinate.

Management

Timely harvest and discarding of severely infested rhizomes during 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 rhizome scale infestation on ginger and turmeric.

Root grubs

Root grubs (*Holotrichia* spp.) sometimes cause serious damage to ginger plants in certain regions of northern India. The grubs feed on roots and newly formed rhizomes. The pest infestation leads to yellowing of leaves and in severe infestations the pseudostems may be cut at the basal region. The entire crop may be lost in severely infested plantations. The adults emerge in large numbers with 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 cowdung is effective for the management of root grubs. However in severely affected areas, drenching with chlorpyriphos 0.075% may be necessary along with mechanical collection and destruction of beetles.

Future thrusts

- Determining economic threshold levels for insect and nematode pests
- Development of diagnostics for management of pests and diseases
- Characterization of pests and pathogens and their biocontrol agents
- Developing strategies to manage new and invasive pests and diseases
- Development of sustainable IPM strategies including cultural methods, resistant lines, biocontrol agents, botanicals, microbials and need-based application of pesticides

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Production system and health management in seed spices

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Spices have a vital position in human life since time immemorial. Kingdoms rose and lost because of spices; continents were discovered because of spices,; have incredible nutritional value; it is essential even as medicine apart from all the above spices are low-volume and high value commercial crops, playing an important role in agricultural economy of the country. A group of spices which are annuals whose dried fruits or seeds are used as condiments constitute the Seed spices. In other words, the seed spices are aromatic vegetable products of tropical origin and are mostly used in pulverized state, primarily for seasoning or garnishing food and beverages. They are characterized by pungency, strong odour, sweet or bitter taste. Out of the 20 seed spices grown in the country, ten are considered more important, viz., coriander, cumin, fennel, fenugreek, Ajowain, dill, celery, aniseed, nigella and caraway. Out of these, the first four are major seed spices not only for home consumption but also for improving economic status of farmers at large.The crop covered as major seed spices are coriander, fenugreek, cumin, fennel and ajowain whereas dill, celery, caraway, nigella and anise constitute minor group of seed spices.

Seed spices production status

Seed spices crops are extensively cultivated in the arid and semi arid region of India during rabi season covering an area of 12.45 lakh ha with production of 9.4 lakh tonnes annually. In India, major area covered under different seed spices is 5.07 lakh ha in coriander, 5.27 lakh ha in cumin, 1.03 lakh ha in fenugreek, 0.74 lakh ha in fennel and 0.20 lakh ha in ajwain with their production in the country is 4.16, 2.83 0.96, 1.14 and 0.163 lakh tonnes, respectively. The productivity of coriander, cumin, fenugreek, fennel and ajwain was 8.20, 5.37, 9.30, 15.41 and 7.85 q/ha.

Seed spices demand status

The prevailing world wide demand for seed spices is more than 200000 tonnes, of which India alone contributes 142300 tonnes annually (2009-10) valued at Rs. 985.6 crores. India is exporting only around 15 percent of its production. There has been an ever-increasing demand of seed spices and importing countries look at India, as consistent source. Keeping this in view, seed spices are considered not only cash crop but also they can be termed as “dynamic crop commodities” particularly in the view of their great export potentially. There is good potential for increase in export of seed spices, if quality is improved This is a great challenge for us as other countries like Bulgaria for coriander, Syria for cumin, Egypt for fennel, Morocco for fenugreek are competing with higher yield per unit area.

Seed spices export status

India commands leading position in world total spices trade with 48% (502750 tonnes) share in volume and 43 % (Rs 556.0 crores) in value. The seed spice export from India has registered an all time high both in terms of quantity (142300 tonnes) and value (Rs 985.6 crores) which accounted for 27.90 % by volume and 17.72 % by value of total spice export from India during 2009-10. In comparison to 2008-09, there was 5.2 % increase in volume and 3.6 % increase in value of seed spice export from India. The major market for different seed spices are USA, UAE, UK and South Africa.

Pre requisites for scientific cultivation of seed spices

Climate requirement

Seed spices are tropical crop except fenugreek which is cultivated both in tropical as well as temperate region. These are mainly cultivated as a Rabi season crop while fenugreek is grown in South India as a rainy season crop. During flowering and seed setting phase, a dry and cold weather favour high seed production in all the seed spices. Cloudy weather during flowering and fruiting stages increases incidence of insect pests and diseases. As soon as temperature raises beyond 20^0C most the crops switches over within short time from vegetative growth to reproductive phase.

Soil conditions

Generally all type of soils are suitable for cultivation of the seed spices. However sandy loam to medium heavy soils having plenty of organic material with better fertility status is most suitable. The soil should have better drainage facility because stagnated water and excessive moisture both are very harmful for successful cultivation of cumin. Saline, alkaline and sandy soils are not suitable for the cultivation of these crops. The optimum soil pH should be between 6.0 and 7.5 for the better growth and development.

Field preparation

Field preparation should start with early rain. The land may be irrigated if the moisture is not sufficient. The first ploughing should be done by soil turning plough and afterward 2-3 ploughing should be done by country plough or harrow. The ploughed field should be made fine and levelled by planking. There should be moisture in soil for good germination. In order to manage problem of termite apply Quinalphos 1.5% or Fenvalrate dust 1%, @25kg/ha in soil before planting. The green manure crops *Sesbenia* and guar are grown during *kharif* season for improving soil fertility status

Sowing time

Time of sowing depend much upon the day time temperature. These crops should be sown when day temperature falls below 25^0C. The optimum sowing time for all the crops in North India is between Mid Oct. to Mid Nov. while cumin can be grown up to I week of December. In South India fenugreek is grown as Kharif crop during mid June to last week of July.

Sowing method

Sowing is some time done by broadcasting however line sowing is advisable as this facilitates intercultural operation. Crop geometry should be 25 to 30 cm line to line spacing and 10-15 cm plant to plant distance with 2-2.5cm depth. In case of cumin the seed should not be sown more than 1.5cm depth. Fennel may also be transplanted. For this seed is sown is nursery in the month of June-July and after 45-60 days of sowing in nursery, seedlings of fennel may be planted in the main field. The transplanting of seedling should be done with line-to-line spacing of 45 to 60 cm and plant-to-plant spacing of 20 cm.

Seed rate

Crop	**Seed rate**
Coriander	10-16 kg/ha seed.
Cumin	12-16 kg /ha
Fennel	2.5 kg/ha seed is required for raising seedling in nursery 8-10 kg/ ha seed is required for direct seeding
Fenugreek	Deshi methi 20-25 kg/ha Kasuri Methi 8-10 kg/ha.

Seed treatment

For seed borne fungal diseases, seed treatment with Bavistin @ 2g/kg or Captan or Thiram @ 3g/kg seed is recommended. Biological agents like Trichoderma (@4-6 g/kg seed), Azotobacter, Phosphate Solublising Bacteria (PSB) in case of coriander and seed treatment with Rhizobium culture in case of fenugreek is recommended. Seed soaking before sowing is found to increase germination percentage.

Manures and fertilizers

	FYM	Vermicompost	Sheep manure	N	P	K
Coriander	10t	5t	10t	40	30	20
Fenugreek	10t	5t	7.5t	25	20	20
Fennel	15t	7t	10t	120	50	30
Cumin	10t	5t	10t	60	20	20

Values of N, P, K are expressed in kg/ha

Constraints and challenges in production of seed spices

Though India is largest producer, consumer and exporter of seed spices but level of productivity of most of the seed spices is low. Moreover, there is no consistency in yield and productivity of seed spices. This might be due to lot of constraint and challenges in production of major seed spices.

Constraints and challenges in seed spice production

The low productivity of seed spices is primarily due to the non availability of high yielding disease resistant varieties with less responsiveness to climatic adaptation. Another major cause for the low productivity of seed spices is that they are grown under deficit moisture with poor management practices in Rajasthan and Gujarat. However development programme are slowly changing the outlook of the farmers to adopt better management practices. The major constraints faced by seed spices have been identified and categorized in four categories.

1. Agro ecological constraints
2. Biological constraints
3. Managerial constraints
4. Socioeconomic constraints

Agro ecological constraints

Production and productivity of seed spices is decided by agro ecological setting of the region. Seed spices can be grown successfully in specific agro ecological setting required for them. Almost all the seed spices are grown in arid and semi arid region of our country Uncertain and insufficient rainfall during the calendar year affecting water table and water quality. Organic carbon content and fertility status of the soil is poor Apart from it the land of this area have poor water holding capacity hence it require frequent costly irrigation. Fluctuation in weather conditions may result frost injury as well as high humidity during growing season which is congenial for blight disease.

Strategies to overcome agro-ecological constraints
Integrated nutrient management in seed spices

Nutrient refers to all those compounds, which are required by the plant as a source of body building material and for the energy, without which it will not be able to complete its life cycle. The seed spices nutrition is concerned with the provision of plant with nutrients as well as nutrient uptake and their distribution in their plant system. Integrated nutrient management refers to maintain the soil fertility and plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefits from all possible sources of plant nutrients in an integrated manner. Therefore, it is holistic approach, where we first know what exactly required by the plant for optimum level of production, in what different forms these nutrients should be applied in soil and at what different timings with the best possible method, and how best these forms should be integrated to obtain the highest productive efficiency on the economically acceptable limits in an environmental friendly manner. Therefore, integrated use of all source of plant nutrients is needed to check the nutrient depletion and maintain the soil fertility and productivity of sees spices. Sources of nutrients in INM include chemical fertilizer, biofertilizers, organics like compost, FYM, vermicompost, green manures, crop residues and agronomic practices like crop rotation, intercropping etc.

Water management in seed spices

Seed spices are mainly grown in arid and semi arid regions of our country having medium to low precipitation, high wind velocity and poor water holding capacity in soil. Thus under such scenario, water management for seed spices is an important aspect of crop management for realizing higher yield with better water use efficiency. The water resource of arid and semiarid region is scarce and its replenishment is also very poor and large part of rain and irrigation water is lost through evaporation and deep percolation. Generally, under surface irrigation methods, only less than one half of the water released is utilized. A significant part of the applied water is lost in conveyance, application, runoff and evaporation. Accordingly, the efficiency of surface irrigation is low. The conventional systems of irrigation revolve round the concept of replenishing the moisture level to field capacity (FC) after 50 to 60 per cent depletion. The system does not permit the restricting of water to meet the requirement at the root zone, thus leading to excessive percolation and other losses, which results in problem of water logging, soil salinity and even drought like conditions at tail ends of the system. These conditions have created the low productivity levels in irrigated agriculture. Therefore, modern system of irrigation like drip and micro sprinkler are getting importance due to high water use efficiency and low application losses.

Irrigation in coriander

- Coriander is cultivated both as rainfed and irrigated crop.
- Initial moisture is essential for good germination and crop stand.
- Branching, preflowering and seed development stage are critical for irrigating the coriander crop.

Irrigation in fennel

- In comparison to other seed spices, it requires more number of irrigations due to longer crop duration
- 6-10 irrigations during growth period are needed.
- Fennel irrigated at 0.8IW/CPE ratio found an optimum in surface as well drip irrigation

Irrigation in fenugreek

- First irrigation should be given at 4-6 leaf stage.

- Seedling, branching, pod formation and pod development stages were critical for irrigating the fenugreek crop.

Irrigation in cumin

- Cumin requires five irrigation at sowing, 8-10, 30, 45-50 and 60-65 DAS
- Irrigation should be avoided when the crop is at maturity stage as this may affect seed quality adversely.

Frost management

Almost all the seed spices are winter season crops and need cool weather conditions for better growth and development. However frost leads to major damage to these crops. Late winter rainfall also adversely affect the quality and quantity of production by infestation of diseases, pests etc. In un irrigated condition the chance of frost attack is more in coriander in North India.

Burning of waste material on the bunds of fields during night is useful protecting the crop against frost. If irrigation facility is available, then irrigate the crop. When the chance of frost is more then spray 0.1% Sulphuric acid at flowering stage, protect the crop from frost.

Biological constraints

Biological constraints include the possession of primitive characters like growth hobbit, profuse flowering, deep root system, flower drop, harvest index and physiological characters. These characters suggest that their demonstration was aimed more at survival under adverse conditions rather than for higher yields. The major biological constraints resulting in low productivity of seed spices is susceptibility to weeds, disease and pest.

Integrated weed management in seed spices

Weeds are the major constraint for successful crop production. They complete with crops for nutrient, light, water and space as well as causes several adversities like harbouring of insect pests and diseases, difficulties in harvesting and threshing, deteriorate the quality of produce etc. Initially, all seed spices are slow growing in nature. Hence, they are more prone to severe competition with the weeds for nutrients, light, water and space resulting heavy reduction in yield. The degree of weed infestation in seed spice crops may vary from field to field and season to season due to differences in climate, cropping pattern, soil fertility, water management practices etc. Weeds, if not controlled in time can cause huge losses in yield and quality of seed spices. In seed spices production, weeds not only decrease yield but also deteriorate the quality of crop seeds by way of weed seed contamination. Depending upon the type of weed species, severity and duration of infestation, competing ability of crop plants and also climatic conditions, reduction in economic yield of seed spices has been reported to be 40-45% coriander, 63% cumin, 35-40% fenugreek and 45-50% fennel.

Although manual weeding is still a major practice to control weeds in seed spices, but it is still a major practice to control weeds in seed spices, but it is highly labour oriented, expensive and time consuming. Sometime availability of labour also becomes difficult during busy crop season of other crops.

Therefore, integrated weed management with appropriate amalgamation of manual, chemical, mechanical and suitable cropping system approaches can be more scientific, sustainable, economically viable and environment friendly. No single method of weed control is adequate or cost effective in seed spice crops. Pre-emergence herbicide application in seed spice crops must be followed by at least one inter-cultivation/hand weeding. In seed spice crops mechanical cultivation may damage the seedling and underground parts. In such cases herbicides may be integrated with cultural operations. Solarization is not effective to control Cyperus rotundus; therefore some complementary hand weeding will be necessary. Ensure correct identification of the weed species which are present. The important activities for integrated weed management are as under.

1. Ensure correct identification of the weed species
2. Crop residue management for weed control
3. Management of tillage practices for reducing weed population.
4. Practice of stale seed beds before sowing for ensuring germination of weeds
5. Choose a more competitive crop variety having better crop canopy
6. Consider mechanical methods of weed management.
7. Use an economic threshold limit for use of weed management practices.
8. Consider the role of weeds which may be harbouring beneficial species.
9. Soil solarisation during summer should be done
10. Manual hand weeding should be combined with chemical method of weed control
11. Use of weedicide

Major diseases of seed spices
Wilt

Wilt caused by *Fusarium oxysporum* is one the important diseases of cumin, coriander, fennel and other seed spices, which causes severe yield losses under favourable conditions particularly in cumin. The plants are affected at all crop growth stages, but the severity of wilt increases with the plant age. Generally when the crop is about one-month old the disease appears in the field. In the severe stages, the tips of plants and leaves drop down leading to total mortality of the plants. Infected plants can easily be pulled out of the soil and diseased plant roots showing dark brown makings. Sometimes, only partial wilting is observed. If the plants are infected at flowering stage, they remain sterile. Seeds if formed are thin, small and shrivelled. The pathogen is soil as well as seed-borne in nature.

Disease management: The predominant soil-borne nature and longer period of survival of resting structures of *Fusarium* in the soil have lessened the efforts to manage this disease for profitable cultivation. Among the cultural methods of management, rotation with non-host crops has been found to be the most effective way of managing this disease in the same field. Rotating cumin fields with mustard and pearl millet in winter and rainy season respectively has been found to keep incidence of wilt under check.

- Seed treatment and soil drenching with methyl thio-phanate and carbendazim decreased wilt incidence and increased yield. Seed dressing with *Trichoderma harzianum* T2 isolate also, lowered disease incidence. *Aspergillus versicolor*, isolated from heated (naturally or solarized) cruciferous residue amended soil was found to parasitize *Fusarium oxysporun* f.sp. *cumini* in laboratory test and also reduces its population densities in soil.

- In arid region, where intense solar irradiations and high temperatures are amply available during summer months, harnessing solar heat has been found effective in minimizing cumin wilt incidence in the field. In such region, two or three summer ploughings decreased the wilt incidence significantly.

- Several organic amendments were also found effective in reducing population of *Fusarium* and wilt incidence. Population of *Fusarium* was completely eradicated in the mustard-cake-amended (1%) soil within a period 30 days after addition. Incorporation of this cruciferous amendment also enhanced the population of antagonistic actinomycetes in the soil. Combining summer irrigation with amendment of cruciferous residues during May or June was found highly effective in reducing *Fusarium* population in the field. Amendment of soil with a combination of mustard residues and mustard oil-cakes (2.5 +0.5 t ha^{-1}) was effective in control of *Fusarium* population in soil and incidence of wilt on cumin.

Powdery mildew

The powdery mildew caused by *Erysiphe polygoni* is wide spread and affected almost all seed spices crops. The disease causes considerable yield losses in major seed spices growing areas. It may cause upto 50% yield losses under favourable weather conditions besides reducing the market value of seeds. This is major problem of fenugreek, coriander, cumin, fennel, and other minor seed spices crops dill, ajwain, anise and caraway. The disease generally appears in early February to March in Rajasthan. The symptoms appear as grayish specks on the lower leaves. Under favourable conditions, these specks enlarge and cover the leaf surface with mycelia growth and conidia of the fungus. The young leaves are also soon affected. Stem, flower, umbels and fruits also get converted with fungal growth. Under warm moist conditions, spread of the disease is very rapid. The seeds, if developed will be small, shrivelled and lighter than the normal ones. If the weather conditions and stage of the crop are favourable for the spread of disease, it may develop to such an extent that the infected field appears to be dusted with white flour. The development of the disease is favoured by warm moist conditions, temperature playing an important role. Atmospheric humidity does not appear to be a limiting factor. The late-sown crop, grown under irrigated conditions is usually severely affected.

Disease management: The disease can be managed in the field by timely spray of fungicides. The disease could be effectively controlled by the application of sulphur dust @ 25-28 kg $ha\text{-}^{1}$ at flowering stage and second application @ 13.5 kg per hectare at the time of seed formation. Powdery mildew can also be effectively controlled by spraying with dinocap (0.1%).

Alternaria blight

Alternaria blight caused by *Alternaria burnsii* is a major disease of cumin. The disease is characterized by the appearance of small, isolated, whitish necrotic areas on the aerial parts of plants, especially on the tips of young leaves. These areas gradually enlarge and coalesce with each other, and turn purple, eventually brown and finally black. Under wet conditions infection readily spreads to the stem and blossoms. The succulent leaves and blossoms are more affected and may be killed. In case of very severe infection, there may not be any seed formation. Even if seeds are produced, they are shrivelled, dark-coloured, light and usually non-viable. Temperature 23-28 ^{0} C has been found optimum for the development of blight. *A. burnsii* can over-summer in exposed plant residues in the field and is capable of withstanding long periods of dry conditions in the laboratory.

Disease management: Seed borne inoculums can be eliminated by seed treatment with captan, thiram or difolatan. Spraying with the fungicides, cuman, captan, mancozeb, vitavax, plantvax and blitox are effective. Four sprays of Mancozeb (0.2%) have been recommended for effective control of blight in Gujarat state.

Stem gall

Stem gall caused by *Protomyces macrosporum* is a serious disease of coriander. In India, disease occurs in most of the coriander growing states. The disease causes losses on yield as well as effect on marketability of seeds. The disease manifests itself in the form of small tumour-like hypertrophied swelling on all the aerial parts of the affected plants of the plants like, stem, petiole, flower stalks and vein of the leaves. The swellings are usually elongated and varying according to the severity of disease. The gall is soft fleshy when young later becoming hard and woody, as they grow old. The infected plants are stunted, hypertrophied seeds fail to germinate and also unfit for the use. The infection becomes systemic in the host stem before or during the pre- flowering period, inducing organogentic changes in flowers and fruit due to hypertrophy and hyperplasia.

Disease management: The disease can be managed by seed treratment with thiram (0.25 -0.4%) or captafol (0.2%) and spraying with streptomycin and carboxin 30 days after. It has been observed that early and late sown crop contracted less incidence of stem gall than normal sown crop.

Root rot and collar rot

Root rot and collar rot are mainly the problems of fenugreek, however the disease symptoms also observed in coriander, dill and ajwain. Young plants are more susceptible than old ones. At the seedling stage, rot is recorded up to 50-75 per cent. The disease is severe under heavy waterlogged conditions. Infected plant show poorly developed roots, finer rootlets are either not fully developed or destroyed due to rotting.

Collar rot causes lesions mostly at the collar region. Water soaked lesions appear that ultimately cause damage by rotting of the epidermal or vertical tissue at the collar region causing damping off. As the disease advance, the stem becomes constricted at the base and the plants collapse. The sclerotia of the fungus can survive in the soil for several months, depending upon the temperature and moisture. Initial infection starts from the pre-infested soil. The mycelium goes inside the tissue in all direction, initiating secondary infection and producing sclerotia on the diseased parts. The disease is destructive in high humid and warm environment conditions.The rots are soil borne diseases, captan is effective as seed treatment, a soil mix or soil drench to manage the disease.

Insect pest complex of seed spices

Seed spices crop are known to attract large numbers of insect pest due to presence of high volatile oils which emit special fragrances, attractive flower colour and presence of high quantity of nectars. General pests complex of seed spices ranged from soil insects, sucking pests, seed borer, defoliators and those involved in damage during storage. Most of these pests are polyphagous, attacking variety of vegetation and a few species are exclusive for seed spices. Some of the species causes heavy losses to the crop.

Insect pests complex of seed spices

Pests complex	**Crop stages**	**Common insect pests**
Soil Insects	Seed germination to vegetative growth	Termite and cut worm
Leaf minors	Early vegetative growth	Leaf minor
Sucking pests	Vegetative stage to fruit maturity stage	Aphids, white fly, mite, jassids, thrips, hoppers, seed bug etc.
Seed/Fruit borer	Seed development stage to seed harvesting stage	Seed wasp
Defoliators	Vegetative stage to seed maturity stages	*Helicoverpa armigera* and *Spodoptera litura*
Storage pests	At storage	Cigarette beetle and drug store beetle

Important insect pests of seed spices

Sucking pests

Among various insect pests associated with seed spices crops aphids are major yield limiting factor, as it causes more damage than any other pest on most of seed spices crops. More than one species of aphids found attacking on the many of seed spice crops. Aphids are major yield reducing factor in most of the seed spices crops. The heavy infestation of aphid on most of seed spice crops occurred between January to March and causes the loss of more than 50% of yield in unprotected crop. Adults and nymphs of aphids suck the sap from plants and also produce honey dew secretion on which the shooty moulds are developed which results in failure of fruit production. The maximum multiplication of aphid has found the temperature existed between 20-25^{o}C (Maximum), 2-6^{o}C (Minimum) and 60-65% relative humidity. When the aphid infestation occurs at flowering and fruit stage, the fruits are not formed and, if they are formed, they are shriveled and of poor quality. Thrips is a serious pest of cumin in Rajasthan and Gujarat. In cumin thrips population develop in early stages of the crop and cause heavy losses. It is also pests of fenugreek, fennel, dill and coriander. There are eight species of thrips found attacking on different seed spice crops.

Among the other sucking pests the tetranychidae mite *Petrobia latens* is another serious pest on coriander and cumin. It found infesting semi arid and arid region and causes appreciable damage to coriander and cumin crop in Rajasthan. In cumin the infestation occurs mainly in the flowering stage, early sown crop evade the peak period of activity of the mites. The red spider mite reported to reduces more than 50% yield of coriander crop in Andhra Pradesh.White fly a serious pest of many important crop. In seed spices serious infestation has been reported in fenugreek, coriander and fennel. Heavy infestation of white fly is reported from Andhra Pradesh on coriander, fenugreek and in fennel crop.The jassids are also commonly observed on many seed spice crops. Its serious infestation is reported on fenugreek crop. They are more serious when they occur in the seedling stage, secreting toxin and hampering growth of seedling. Lygus bug damaging various umbeliferous fruits during seed development to maturation stages. During their feeding, they pierce many cells and suck cell fluid. As in Umbelliferae, the endosperms mature more rapidly than the embryo. If feeding occurs in early stage of seed development, both endosperm and embryo are destroyed and whole of the endoplasm remains unaffected.

Seed wasp

Seed wasp is a serious pest of many of seed spice crop infesting on seed of the crops and has been reported from Asia, Africa and Europe, whose larva damage the fruit and survive in them. Crops like dill, coriander, fennel, cumin and ajowan suffer damage from this pest. Infestation occurs at field level but infestation found continues during storage of seed. Approximately 40 percent in fennel, 30 percent in coriander, 27 percent in dill, 20 percent in cumin and 10 percent in ajwan seed damage/hole has been reported at field level

Leaf minor

It is major pest of fenugreek. Leaf minor starts attacking on fenugreek crop at very early stages. It continues mine the leaves of fenugreek up to full vegetative stages /flowering stages. Excessive mining at early growth of the plant retarded the growth and vitality of the plants.

Defoliators

Most of seed spice crop are attacked by defoliators from flowering to seed maturation stages and infests crops like coriander, fennel, fenugreek, nigella and cumin. Defoliator of local origin *Hypera postica*, commonly called the alfalfa weevil reported from southern states infesting fenugreek crops from the first week of February until mid- March.

Soil insects

Cut worm infestation is found serious in some areas. The larvae remain inside the soil near the base of the plant. They remain in hide under the soil during daytime and come above the soil surface at night. At night the larvae feed on voraciously the leaves and tender stems and branches. Termite damage is serious in sandy soils and generally damages various seed spices crops at vegetative growth stage by cut the plant stem near soil surface and falls down. Initially plant look like lodging but ultimately die.

Stored pests

Many seed spices crops losses heavily during storage at farmer's level. Seed Spices like cumin, fennel, coriander, ajowan and anise are attacked by more than one species of stored insect pests. The most common species infesting seed spices during storage are cigarette beetle, drugstore beetle, seed Spices wasp. Others are red rust flour beetle rice moth and almond moth. The insect infestation generally remains undetected until adult are seen. By the time these adult are detected much of seed are already damaged. Infestation level during storage is highly dependent on temperature, humidity, seed moisture and type of storage and damage up to 17 to 25 per cent has been reported during storage of various seed spices crops.

Integrated pest management tactics for seed spice crops

- Sucking pests is more serious in seed spice crops so timely sowing of crop (October to first week of November) may escape heavy population buildup on the crops.
- Apply only recommended dose of fertilizers and irrigation. Excessive use of nitrogenous fertilizers and irrigation make plant succulent and help in higher population build up of sucking pests on the plants.
- Seed spices crop attract large number of predators/parasitoids and pollinators. Conservation of theses by applying safe and selective pesticide help in easy and effective management of most of the pest complexes.
- At early colonization of sucking pests, seed wasp, leaf miner and defoliators spraying of botanical insecticides like Neem Seed Kernal Extract (NSKE) at 5%, Neem oil 2 % give good control and prevent the buildup of large colony on the plants for some time. In case of higher population development spraying of either of Dimethoate 0.03%, Metasystox 0.03%, Imidachlorprid 0.005% or Thiomethoxam -0.025% give effective control. Repeats the spray in 15 to 20 days after first application if necessary.
- In case of higher leaf miner attack in fenugreek crop application of endosulfan or dimethoate @0.03% prevent the crop from damage.
- Application of Phorate 10G@ 10kg/ha or Methyl Parathin Dust 2% @25 kg/ha in the soil near the base of the plant can be useful for cut worm and termite. Apply chloropyriphos 20 E.C. or endosulfan 35E.C with irrigation is also effective control of termites.
- Monitoring of adult moths of defoliators through pheromone trap help in timely management of pests. Application of botanicals like neem oil -2% or NSKE -5% help in early control of pest.
- Application of egg parasitoids like *Trichogramma* sp.@ 50,000 parasitised eggs/week/ha. help in control of most of defoliators.
- In case of higher population development of defoliators application of synthetic insecticides like endosulfan or quinolphos @0.05 % successfully control the pests.
- Most of the seed spices crop during storage can be controlled by fumigation of aluminium phosphide, @ 3 tablets per metric tonne of grin or @ 21 tablets per 28 cubic tonne for closed space and Ethylene dibromide @ 3 ml per quintal or @ 8 ml per Cubic meter space in closed space.

Managerial constraints

Managerial constraints are very important factors which largely affect the yield and productivity of the crop. It is the manager who decides the activities, procurement of material and input and level of production. The important managerial constraints affecting yield and productivity of seed spices are as under:

- Lack of availability of high yielding varieties
- Non availability of sufficient quantity of seeds of improved varieties in time.
- Insufficient and improper extension system which used to give focus on major cereal oil seed and pulse crops.
- Lack of training to the state extension and development workers.
- Lack of minimum support prices for seed spices.

Socioeconomic constraints

The socio economic constraints of seed spices crops largely emerged from the interaction of agro-climatic factors, farming systems and the characteristics of the seed spices themselves. The various socioeconomic factors affecting yield of seed spices are given below:

The most important socio economic factor which prevents farmers from taking up seed spices production in Rajasthan is because farmers are at the poverty level and cultivate very small holding. The first priority of the small and marginal farmers is to grow enough cereals for his own consumption so as to keep himself away from market borrowing and purchases.

Strategies for increasing seed spice production and quality

The productivity of seed spice crops will have to be increased to a level which they can compete on equal footing with other crops so that farmers can invest and take up production of seed spice crops. For getting quantum jump renewed research efforts are to be put to develop high yielding varieties which will responds to high doses of inputs including fertilizers and other agronomic management practices. There is need to develop disease resistant varieties with the help of biotechnology. Organically production of seed spices, quality management, post harvest technology and promotion of value added seed spices to be considered at large scale by the researches and planners in future to get more returns with high B:C ratio. The strategies for increasing yield and production of seed spices are as Evolving early maturing varieties suitable different intercropping system and crop rotations

- Breeding varieties resistant to biotic and abiotic stress.
- Physiological aspects to improve quality and quantity of seeds.
- Standardization of appropriate crop geometry.
- Thrust on creation of biodiversity, germplasm collection and their evaluation and characterization.
- Standardization of location specific technology.
- Site specific nutrient, management based on targeted yield of seed spices.
- Deciding efficient and effective irrigation scheduling of seed spices.
- Isolation of efficient strain of fungus for bio-control of disease.
- Seed production post harvesting handling and storage.
- Introduction of processing industries.
- Production of seed spices organically and sustainability.
- Use of biotechnology to develop transgenic for quality improvement and disease resistant.

Production system and health management in tree spices

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India is a "Land of Spices" where each state cultivates one or other spice and Indians use spices generously in their culinary preparations as well as in traditional medicine. Only nine percent of our spices production is exported to more than 100 countries and remaining consumed internally. India commands a formidable position in the world spice trade with 45% share in volume and 30% in value. The major destination of Indian spice exports during 2005-06 are USA, followed by Malaysia, UK, China, Germany, Japan, UAE, Sri Lanka and Singapore.

Tree spices are tall plants, with more canopies, compared to other spices, like rhizomatous spices, seed spices, herbal spices. Therefore, seventeen tree spices grown in different parts of India. Among these six tree spices are like, all spice, Cinnamon, Clove, Curry leaf, Nutmeg and Tamarind are relatively more important.

As there is an import of tree spices into India and drain considerable economy, this could be reduced by introducing these crops as mixed or inter crop in coconut gardens by adapting suitable production packages. The availability of quality planting materials of new varieties is an important constraint.

Allspice (*Pimenta dioica.* L.)

Pimento dioica (Family: Myrtaceae) is a polygamodioecious evergreen tree, the dried unripe fruits of which provide the culinary spice pimento of commerce. The flavor of allspice is a combination of the flavor of clove, cinnamon and nutmeg and hence the name. The dried mature but unripe berries, berry oleoresin, berry oil and leaf oil are the products of commercial importance obtained from *Pimento dioica* and they find varied uses in food, medicine and perfume industries. The dried, mature but not ripe, berries are pimento spice of commence. The dried berries contain aromatic steam volatile oil. The yield of berry oil ranges from 3.0 to 4.5%.

The major use of allspice is in the food industry (65-70%). A small quantity is used for domestic use (5-10%), for production of oleoresin (1-2%) and in pharmaceutical and perfume industry. The tree is indigenous to West Indies (*Jamaica),* which is the major producer and exporter of the spice.

Medicinal value of allspice

The powdered fruit of all spice is used in traditional medicine to treat flatulence, dyspepsia, and diarrhea and as a remedy for depression, nerrous exhaustion, tension, neuralgia, and stress. In small doses it can also help to cure for rheumastism, arthritis, stiffness, chills, congested coughs, bronchitis and neuralgia. It has anesthetic, analgestic, antioxidant, antisepetic, carminative, muscle relaxant, rubefacient, stimulant and Purgative properties (Rema and Krishna Murthy, 1989). It is also useful for oral hygiene and in case of halitosis.

Allspice is reported to have antifungal and antibacterial properties. It is also a nematicide (Leela and Ramana 2000), and insecticide (Bhargava and Meena 2001). The oil is used in perfumery, notably for oriental fragrances. It is used as a fragrance component in perfumes, cosmetics, soaps and after shaves. Allspice is a small, functionally dioecious evergreen tree.

Varieties

In India, trees are available in Maharashtra, Tamil Nadu, Karnataka and Kerala. Though few high yielding trees are available no specific varieties in allspice exist in India. However, germplasm of all spice is being conserved at various research stations (Indian Institute of Spice research, Calicut, Regional Research Station, Ambalavayal, Konkan Krishi Vidya Peeth, Dapoli, etc.) in India to evaluate the performance of the tree in India.

Propagation: Seeds, vegetative propagation. Approach grafting on its own roots rock was more successful in India (90%).

Planting and after care: 1:10 *Male: Female ratio*

Allspice does not set fruits in the plains, spraying paclobutrazol was reported to induce flowering in allspice and further spraying of indoleacetic acid + benzlaminopurine induces fruit set in allspice (Krishnamoorthy *et al.* 1995).

Yield: 10 kg green berry / tree / year. Berries dried for 5-10 days (12-14% moisture) 100 kg green berries gives 55-65 kg dried berries.

Future thrusts

High yielding early bearing trees are to be identified and multiplied by suitable vegetative propagation method. Profusely branching, dwarf / semi dwarf type must be popularized.

Clove

Clove (*Syzygium aromaticum* L.) is an important tree spices, indigenous to Moluccas Islands. The clove of commence is the dried fully grown unopened flower buds of the clove tree, belonging to the family Myrtaceae.

Indonesia, Tanzania, Madagascar, Malaysia, Brazil, Sri Lanka, Haiti and India are the major clove growing countries. The Islands of Zanzibar and Pemba (*Tanzania)* are the world's largest producer of clove, which supplies 90 per cent of the total demand followed by Indonesia. In India, clove trees are distributed in Tamil Nadu, Kerala, Karnataka and Andaman and Nicobar Islands. The domestic Consumption of cloves in India is about 4000 tonnes per annum. The cultivation of clove is confined mostly to South India.

Table 1. State wise area and production of clove in India

Sl. No.	**State**	**2002-03**	
		Area (ha)	**Production (t)**
1	Kerala	754	52
2	Karnataka	359	199
3	Tamil Nadu	777	785
4	Andaman and Nicobar	95	4
	Total	1885	1040

India imports clove from Tanzania, Singapore, Malaysia, Sri Lanka, Indonesia and China. The tree is slender, ever green which grows to a height of 15-20 m, medium sized, straight trunked with Semi – erect braches and brittle limb bearing bushy and dense canopy heads and grayish bark. Flowers borne at the terminal ends in small bunches hermaphrodite in nature. Entire inflorescence is of about 5 cm long and 3-4 flowers are present in each peduncle. Each flower has a cylindrical thick ovary and is surrounded by the plumb ball like unopened corolla which is surrounded by four toothed calyx, with sepals 4, fleshes, triangular, petals 4, stamens numerous, style short, stigma 2 lobed. Fruit fleshes purplish one-seeded oval fruit (drupe) known as mother of Clove (Krishna Moorthy and Rema, 1993). Self pollination is reported to be more probable mode of pollination in clove as maximum pollen Viability and stigma receptivity are attained simultaneously (pool and Bermanwie, 1986). However, flowers are frequently visited by ants, thrips, and bees suggested the self or cross pollination by insect.

Varieties

Generally local types are under cultivation and no true variety of cloves is recognized. In trade, differences are recognized according to the country of origin. Penang cloves are considered superior in quality followed by Zanzibar and Madagascar. Propagation is by seeds and favours self pollination, seedlings are true to type.

Vegetative propagation

Approach grafting can be grafted throughout the year with maximum success of 87% during September – November (Rema and Krishnamoorthy, 1994).

Shade management: Banana, cassava, *Glyricidia* sp., *Erythrina* sp and black pepper + clove.

Irrigation: 10-20 litre of water thrice a week per plant for optimum growth.

The basin of the tree is mulched with dry leaves. Application of 8 litre of water/tree/day through drip irrigation has been found beneficial in enhancing tree vigour.

Medicinal values of clove

The oil is used as on ingredient for many tooth pastes, and mouth washes. The whole or ground clove is also used in medicine as carminative and stimulant and used to cure flatulence, indigestion, and dyspepsia, externally, it has a counter-irritant action. It is useful in pain killing, fighting infections and preventing sluggish circulation. The therapeutic properties include analgesic, ant neuralgic, ant infections, disinfectant, insecticidal and tonic. It stimulates mind and memory and relieves mental fatigue. It also contains antioxidants which prevents cancer. It is an effective remedy for asthma. Its oil relieves from muscular pain when applied as poultice. The clove oil and its derivatives inhibited the growth of Aspergillums Niger and penicillium expansum. The major component of clove inhibiting Rhizoctonia damping-off of cabbage seedling was eugenol.

Cinnamon

Cinnamon (*Cinnamomum verum*) is one of the earliest known spice and the dried inner bark of the tree is used as spice. Cinnamon is a native of Sri Lankan. Since it is mostly raised as a rainfed crop, an annual rainfall of 200-250 cm is ideal. At present seven varieties of cinnamon are available for cultivation in various parts of the country. The Varieties of cinnamon available for cultivation in India are IISR Navashree, IISR Nithyashree, YCD-1, PPI – 1, Konkan Tej, RRL (B) C-6 and Sugandhini.

Table 2. Characters of cinnamon varieties released from Indian Institute of Spices Research

Sl. No.	Variety	II SR Navashree	IISR Nithyashree
1	Pedigree	Seedlings selection from Sri Lankan Collections	Seedling selection from Indian collections
2	Area of adaption	All cinnamon growing area in India	All cinnamon growing area in India
3	Harvest	Three years for first harvest	Three years for first harvest
4	Average yield	200 kg dry quills/ha	200 kg dry quills/ha
5	Bark oil (%)	2.7	2.7
6	Leaf oil %	2.8	3.0
7	Bark oleoresin (%)	8.0	10.0
8	Bark recovery (%)	40.6	30.7
9	Eugenol in bark oil (%)	6.0	5.0
10	Eugenol in leaf oil (%)	62	78

The cinnamon varieties released from Tamil Nadu Agricultural University are YCD-1 and PPI(c)-1. The cinnamon varieties released from B.S.K.K.V.Dapoli is Konkn Tej. The cinnamon varieties released from Kerala University is Sugandhini. The cinnamon varieties released from OATU Bhubaneshwar is RRL (B) C-6.

Medicinal uses of cinnamon

Cinnamon bark, twigs, and leaves possess several medicinal properties and are used in Ayurveda and Sidha medicinal preparations.

- Digestive ailments
- Mild antifungal properties and also prevents spoiling of food
- Improve brain function and memory
- Lowering of blood glucose and Cholesterol levels

Curry leaf

Curry leaf (*Murraya Koenigii*) The tree is native to India and is found growing wild in the Indian sub continent. About 893 tonnes of Curry leaves were exported from India 2002-2003 (*Anonymous 2005)*. The Southern State of Tamil Nadu is one of the major Curry leaf Producing State.

Flowers are bisexual, white, funnel shaped, sweetly scented, stalked, complete, ebracteate, regular, actinomorphic, Pentamerous, hypogynous, the average diameter of a fully opened flower being, 1.12 cm, inflorescence, a terminal cyme, each bearing 60 to 90 flowers, calyx, 5 lobed, persistent, inferior, green, corolla, white, polyentalous, inferior, with 5 petals, lanceolate, length, 5mm, androecium, polyandrous, inferior, with 10 stamens. Gynoecium, 5 to 6 mm long, Stigma, bright, stickey, style, short, ovary, Superior. Fruits are round to oblong, fully ripe fruits, black with a very shining surface, pulp, wistaria blue, the number of fruits per cluster varying from 32 to 80. There are only one seed in each fruit.

Varieties

Classical breeding has not been carried out in curry leaf. Even the existing diversity has not been properly utilized. The promising varieties developed so far, DWD-1 (Suvasini), a clone of root sucker with dark green leaves and strong aroma. DWD-2 is a seedling progeny with ashy green leaves and strong aroma. Savadati local (SL) is similar in external appearance as that of DWD-2 but more vigorous, and old garden seedlings with less vigour and small leaves (Bhagavatagoudra and Madalageri, 2001). A new cultivar Suwasini was developed by Hiremath and Madalageri (1997). The leaves of this cultivar gave an essential oil yield of 0.44% when hydrodistilled.

Seed propagation

Seeds are sown immediately after harvest in raised beds for raising the nursery at a spacing of 10 cm. they geminate within 3 to 5 days. Two to three week old seedlings are transferred to poly bags filled with normal potting mixture of garden soil and well powdered cowdung in a ratio of 3:1. When, they are one year old, they are planted on the main field.

Suckers
Planting: Spacing of 0.75 m (Lalitha *et al.,* 1997 a, b)

High density (2200 plants / ha) bush culture increased the number of harvests (4) per year and produced higher biomass yields (22 t/ha) than tree culture.

Fertilizer: 200g N + 100g P_2O_5 + 100g K_2O / plant and pruning branches at 1m for obtaining higher annual yield.

Irrigation: 3 year old bush required 19-22 litres of water / day for optimum yields.

Cropping System: Curry leaf is recommended in coconut garden in Tamil Nadu under multispecies cropping system (Merimuthu *et al.,* 2001).

Harvest: The plant will be ready for the first picking six months after planting, from the second year, three harvests can be made every year. Yield: 25 to 50 tonnes / ha depending on the age of trees.

Value addition: Hydro-distillation of essential oil from fresh leaves.

Powder: Conversion of fresh curry leaves in to dry powder oven drying at 50^0C.

Medicinal use

Leaf essential oil and *carbazole alkaloids* curry leaf has been used in folk medicine in china and other Asian countries as an analgesic, astringent, antidysenteric, antioxidant, febrifuge, hypolipidanemic, hypoglyesic, for improvement of vision to treat night blindness, and for regulation of fertility (Palani Swamy *et al.,* 2003). It is used in traditional medicine to treat constipation, Colic, diarrhea and hiccups (Kumar *et al.,* 1999).

Nutmeg

Nutmeg (*Myristica fragrans* (Houtt), a native of Moluccas Island is the dried seed of the peach like ripe fruit of *Myristica fragans* (Houtt) which yields two spices, viz., nut and mace. Indonesia is the largest world producer of nutmeg and mace followed by Grenada. Sri Lanka and India are the other producers of nutmeg.

Table 3. Area and production of nutmeg in India

Sl. No.	State	Area (ha)	Production 2002-03 (t)
1	Andaman and Nicobar	21	2
2	Karnataka	228	96
3	Kerala	7601	1888
	Total	7850	1986

Composition

The Principlal constituents of nutmeg are fixed oil (fat), Volatile oil and starch (6-16%). Native of the eastern islands of Moluccas Nutmeg is a handsome evergreen tree with dense foliage Trees are 10-20 m tall, branches are spreads with dark gray bark, leaves are shiny. It is usually dioecious, plant, It is strictly cross-pollinated crop, the plant differ in growth and vigour (Anon, 1989) (Krishnamoorthy, *et al.,* 1996).

Fruit is pendulous, broadly pyriform, yellow, smooth, 7-10 cm long, fleshes, splitting open into two halves when ripe. Individual nutmeg fruits weighed on an average 60 g of which the seed weighed 6.7 g, mace 3-4 g and rest pericarp. Krishnamoorthy *et al.* (1996) found that the fruit weight of nutmeg ranged from 60.5 to 80.0 g. The seed weight from 8.4 to 12.2 g and the mace weight from 2.5 to 3.7 g.

Varieties

1. Konkan Sugandha : Yield 526 fruits /tree /year
2. Konkan Swad : 761 fruits /tree /year
3. Konkan Shrimati : --
4. IISR Viswashree : 3122 kg dry nuts/ha, 480 kg mace /ha 8th year

Propagation by seed

Epicotyl grafting
Soft wood grafting
Planting : 8.0 x 9.0m or 6.0 x 6.0 m
(Shade or mixed crop on coconut and Arecanut)

Uses

Nutmeg is a stimulant, carminative, astringent, aphrodisiac, and hallucinogen. It is used in tonics and forms a constituent of preparations prescribed for dysentry, stomachache, flatulence, nausea, vomiting, malaria, rheumatism, sciatica, and early stages of leprosy. Oil of nutmeg or mace is employed for flavouring food products and liquers, soaps, tobacco dental creams and perfumery products. Fleshy pericarp of the fruit is used for making pickles and jelly.

Tamarind

Tamarind (*Tamarindus indica* L.) belongs to the family Leguminosae, subfamily caesalpinne. It is a native of tropical Africa. Tamarind is a hardy tree which grows well under warm climatic conditions of tropics. It is drought tolerant and grows in sandy soil. It is preferred as a wind break. Tamarind trees are generally, raised on road sides in back yards, on the buds of field and in waste lands. In India, the fruits are used mainly for culinary purposes, while in other countries the fruit is processed into nector, fruit punch, juice, crystallized fruit and concentrates. The pulp is used to season many foods, viz., Chutneys, Curries, preserves, confectioneries. The pulp possesses some medicinal value. The tamarind seed powder commercially known as tamarind kernel powder (TKP) is used as a creaming agent in manufacturing of tuber and latex as a substitute for cereal starch. Wood is used for agricultural implements too handles etc.

In Thailand the tartaric acid content varied from2.5 to 11.3% and the sugar from 5.0 to 40.0%. According to *Feungchan et al* (1996), the tartaric acid content of sweet tamarind in Thailand was as low as 2.0 to 3.2% and the sugar was as high as 39.1 to 47.7%. The fruit pulp after removing the fibres, is mixed with sugar, wrapped and sold as toffees. The pulp is also used to make sweet meats with sugar called tamarind balls (*Purseglove,* 1987). In India, the pulp is eaten raw and sweetened with sugar.

Table 4. Chemical composition of sweet tamarind pulp from Thailand

Sl. No.	Cultivar	Tartaric acid (%)	Sugar (%)	Acid/Sugar ratio	Fibre (%)
1	Sithong	3.18	41.07	1:13	1.44
2	Piyai	2.01	47.19	1:23	1.97
3	Praroj	2.70	43.09	1:16	0.88
4	Srichompoo	2.39	42.52	1:18	1.96
5	Kru-in	2.70	39.06	1:14	1.02
6	Jachom	2.98	47.71	1:16	1.33
7	Pananikom	2.34	47.71	1:20	1.10

(Source: Feungchan *et al*., 1996)

Tamarind exhibits huge variations for economically important traits. Variation for fruit characteristics, such as length of pod, pod weight, seed number, pod colour and sweetness of pulp is observed. Considerable variation in fruit yield (150 – 200 kg/ha/year or 800 kg/tree/year) of tamarind have been reported in different countries showing the potential for improvement of fruit production.

The origin of sweet tamarind has been attributed to a point mutation. It is also assumed that the sweetness in tamarind is a rare trait, which may be governed by recessive genes, isolated branches on a tree may bear sweet fruits, while the other branches have the normal sour type. Grafted plants from these trees are maintained to serve as source of bud sticks for large scale propagation and distribution. Bud spots are also commonly found in the Philippines. These are isolated branches bearing sweet fruits from normally sour tamarind trees. Theses bud spots will provide ample opportunities for genetic improvement of tamarind.

Germplams evaluation in India

Selection such as prathisthrn from Maharashtra and Periyakulam (PKM-1) and Urigam from Tamil Nadu are well established and preferred by farmers, but its performance in Karnataka (Bellary district) is very poor (Hanamashetti, 2006). There is perfuse flowering in case of PKM-1, but no fruit set. Periyakulam (PKM-1) is a sour type, a clonal selection from a local variety of a village, namely Endapalli near periayakulam. It is an early bearer and the grafts come into bearing from the third year against the fifth year in the local cultivars. It has a pulp recovery percentage of 39% compared to the local cultivars which is 28%. The yield is also higher in the periyakulam cultivar with 263 kg per tree against 167 kg per tree in the local cultivar.

Table 5. Selected tamarind cultivars grown in some countries

Sl. No.	Country	Cultivars
1	Thailand	Muen Chong, Sri Tong, Nam Pleung, Jae Hom, Kun sun, Kru Sen, Nazizad, Sri Chompoo
2	The Philippines	Cvite, Batangos, Bulacan and Laguna
3	India i) Maharashtra	 Prathistahn, Yogeshwari (Red flesh)

	ii) Tamil Nadu iii) Karnataka	Periyakulam (PKM-1), Urigam Dharwad Tamarind Selection-1 (DTS-1) Dharwad Tamarind Selection-2 (DTS-2)

Azhakiamanavalan and Vadivel (1997) reported the performance of PKM_1 tamarind released during 1992, PKM-1 performed better with superior yield, pod characters compared to local and registered a mean yield (4 years from 1988 – 1991) of 263.6 kg per tree as against 165.0 kg per tree in local cultivar. The yield is 26.3 tonnes per hectare as against 16.5 tonnes in the local at the spacing of 10 x 10m, PKM-1 exhibited precocity in bearing. Flowering in September – October, matures in February – March and harvest can be done during March – April under periyakulam conditions.

At fruit research Station, Himayatbagh, Aurangabad, Pratisthan, and Number 263 stand were released for commercial exploitation. At Ambajogai, a unique red fleshed tamarind tree was located which is released as yogeshwari (Karale *et al.,* 1997). University of Agricultural Sciences, Dharwad released two varieties during 1996 based on the clonal progeny performance *viz*., Dharwad Tamarind Selection-1 (DTS-1) and Dharwad Tamarind Selection-2 (Hanamashetti, 1996).

Table 6. Performance of DTS-1 and DTS-2 Tarmarind

Variety	Pod yield kg/plant		Number of pods per kg
	4th year	10th year	
1. DTS-1	2.5-3.00	56.00	70.00
2. DTS-2	2.00 -2.50	44.20	75.00

Patil (2004) surveyed the Dharwad and Gadag district of Karnataka. The pod yield recorded from different plus trees ranged between 250 kg per tree in tree number 108 (Balehosur, BLH-3) to 800 kg per tree in tree number 92 (Mulgund, MLG-1).

Dehulling

The Dehuller has been developed at the PHT centre, UAS, Bangalore to improve efficiency and eliminate drudgery the unit is more efficient when fed with large sized curred fruits (hulling per cent of 79.48), while it is low in small size fruits (58.47% hulling). The hulling capacity is 500 kg per hour. Ramakumar *et al*. (1997) conducted research on development of a tamarind dehullar and short term storage of pulp. The study clearly showed that the tamarind dehuller developed is energy and time efficient compared to traditional method.

Storage of pulp

Qualitative and quantitative changes in the tamarind pulp upon storage is reported upon storage, the moisture content decreased from 30% to around 20% (Babu et al., 1999). The original brown colour was retained up to 4 months storage in metal and black polythene. Tamarind can be stored up to two to three years in cold storages without loss of quality and quantity (colour, weight and sourness).

Processing and product development

Tamarind fruit has been used as a raw material for the manufacture of several products like tamarind juice concentrate (TJC), tamarind pulp powder (TPP), tamarind kernel powder (TKP), tartaric acid, pectin, tartarate and alcohol. The yields of which are presented in table 7.

Table 7. List of products from tamarind

Sl. No.	Product	Yield %
1	Tamarind juice concentrate	75-80
2	Tamarind pulp powder	80-85
3	Tamarind kernel powder	55-65
4	Tartaric acid powder	8-10
5	Pectin powder	2-3.5
6	Tartarate powder	10-12
7	Alcohol	10-13

Medicinal value of tamarind

The pulp is said to improve appetite, it is available commercially in tablet form in Thailand for the reduction of excess weight, Tamarind pulp alone or in combination with lime juice, honey, milk, dates, spices or camphor is used as digestive, even for elephants and as a remedy for biliousness and bile disorders.

Tamarind has been used in the treatment of a ailments, including the alleviation of sunstroke, datura poisoning and the intoxicating effects of alcohol and ganja (*Cannabis sativa* L.). It is used as a gargle for sore throats, dressings of wounds, and is said to aid the restoration of sensation in cases of paralysis. In Brazil, both the fruit pulp and leaf are regarded as purgative, diaphoretic and emollient. In South –east Asia, the pulp is prescribed to contract the ill effects of over doses of chaulmoogra (*Hydnocarpus anthemintila* Pierre), which is given to treat leprosy and in Mauritius, the pulp is used as a treatment of rheumatism.

Conclusions

Seventeen tree spices grown in different parts of India. Out of which spices like allspice, cinnamon, clove, curry leaf, nutmeg and tamarind are relatively more important. The flavor of Allspice is a combination of the flavor of clove, cinnamon and nutmeg and hence the name. The powdered fruit of allspice is used in traditional medicine to treat flatulence, dyspepsia, diarrhoea and as a remedy for depression, nerrous exhaustion. High yielding early bearing trees are to be identified, the domestic consumption of cloves in India is about 4000 tonnes per annum, where as the production is only 1040 tonnes. The essential oil of clove is used in pharmaceutical preparations, as remedy for toothache. There is need to identify regular and heavy bearing cultivars, with dwarf, bushy, nature and bold cloves. At present seven varieties of cinnamon are available for cultivation in various parts of the country, viz., IISR Navashree, IISR, Nithyashree, YCD-1, PPI-1. Konkan Tej. RRL (B) C-6, Sugandhini, Cinnamon bark, twigs, and leaves possess several medicinal properties and are used in Ayurveda and sidha medicinal preparations.

Curry leaf is native to India and is found growing wild in the Indian sub continent. The promising variety developed is DWD-1 (Suvasini). Bush method of cultivation gave higher yield (22 t/ha), than tree culture. It is used in traditional medicine to treat constipation and diarrhea. Nutmeg (*Myristica fragrans)* which yields two spices, (nut and mace), is a stimulant, carminative and astringent. High yielding nutmeg varieties are Konkan Sugadha, Konkan swad, Konkan Shrimati, IISR Viswashree. Tamarind is native to tropical Africa, hardy tree which grows well under warm conditions of tropics. The high yielding varieties are prathisthan, Yogeshwari (Red flesh), Periyakulam, (PKM-1), Urigam, Dharwad Tamarind Selection-1 and 2 (DTS-1 and DTS-2). In Thailand the sweet tamarind varieties grown are Muen Chong, Sri Tong, Nam Pleung, Jae Hom, Kun Sun, Kru Sen, Nazizad, Sri Chompoo, which are in more demand in Indian market also. The pulp is said to improve appetite, reduction of excess weight, used for digestion. There is need to develop package of practice for tamarind cultivation in a scientific way.

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Recent developments in vacuum packaging of chilli for extended shelf life

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Investigations were carried out to study the influence of vacuum packaging and long term storage on quality of red chilli pepper and powder in the Department of Crop Physiology, University of Agricultural Sciences, Dharwad, Karnataka. The experiment consisted of 10 treatments combinations involving two moisture levels and three storage conditions. Results revealed that the initial moisture content was maintained in vacuum even upto twelve months of storage, while in gunny bags, it fluctuated between different storage periods. No appreciable reduction in quality parameters viz., oleoresin extractable colour, total extractable colour, capsaicin content and moisture content were noticed during the storage period. There was an average 9.4% decline in the capsaicin content in the vacuum treatments, irrespective of storage conditions and moisture levels, while in gunny, thre was an average decline of 43.6%. With respect to oleoresin extractable colour, the least per cent decline (6.6) was observed in cold stored vacuum with 10% moisture. In general, the vacuum bags kept at room temperature registered a greater decline (11.2%) compared to cold storage. The oleoresin extractable colour was almost reduced to half (49.8% decline) than the original at 12 months of storage under gunny at room temperature. On an average, the gunny stored treatments registered 45% decline in oleoresin extractable colour at the end of the storage period. A similar trend was observed with respect to total extractable colour, but the magnitude of decline was almost two times for vacuum bags at 12 months of storage, while for gunny, the per cent decline was 51.9.

Vacuum packaging has been found to be a superior technology in preserving the quality of whole chillies for upto 24 months when compared to gunny bags where chilli can be stored for only a short period. Various quality parameters viz., total extractable colour, oleoresin extractable colour and capsaicin content were very high in vacuum packaging treatments compared to gunny bags which are again due to the impermeability of packaging film to air and moisture. Among various treatments, vacuum packed chillies under cold stored were found to have the least per decline in various quality parameters. Chilli with 12 per cent moisture and stored in vacuum packaged bags recorded better quality parameters over 10 per cent moisture reportedly because of moisture protective property against oxidation.

The respiratory rates of whole chilli greatly reduced in the vacuum packed bags may be due to lack of oxygen. The data of seed viability studies indicated that the viability can be maintained even after 24 months with 90 per cent germination in the vacuum packed bags with very high seedling vigour index compared to traditional storage methods. The maintenance of viability under vacuum packaging could again be due to lack of oxygen, since temperature and oxygen are the most deterrents for seed deterioration.

Vacuum packaging of both whole chilli and powder maintained the bioactive compounds *viz.,* capsaicin content, oleoresins, carotenoids even upto 24 months of storage with no appreciable changes. Storing whole chilli in gunny bags and powder in HDPE bags deteriorated various bioactive compounds to tune of >50% at the end of 12 months storage. The novel technology of vacuum packaging for maintaining quality and the status of bioactive compounds needs to be popularized. Indian chillies have an immense scope for export on account of its preference in the world market. Quality promotion should be the motto of our farmers and producers. Vacuum packaging would prove to a boon for chilli growers in the region and enhance the export market. This kind of packing facilitated bulk packing, easy storage and preservation of quality. The respiratory rates of seeds greatly reduced in the vacuum packed bags due to lack of oxygen and maintained viability with 90% germination even after 24 months of storage.

Investigation over a period of 24 months revealed that total extractable colour, oleoresin extractable colour and capsaicin contents were very high in vacuum packaging treatments. Among various treatments, vacuum packed whole chilli powder under cold storage were found to have the least per cent to decline in all the quality parameters compared to controlled treatments where the deterioration was more than 70 percent. Carotenoids estimation data revealed that in these treatments, while ß-cryptoxanthin and lutein contents fully disappeared in these treatments.

In addition to this, vacuum packaging technology can also be extended for seed storage of agricultural and horticultural crop seeds. The applied vacuum inside the package protects from oxidation, insect infestation and microbial spoilage. Consequently, the initial quality of the seed is preserved for longer period. Seed deterioration is a major problem during storage the losses are even greater in the geographical regions where high temperature and high humidity prevent during seed maturation and storage. Considering the importance of preservation both for maintaining the quality of products and viability of seeds, investigation were carried out to study the influence of vacuum packaging on various bioactive compound in chilli and also it influence on seed viability during long term storage.

Seed deterioration is an inexorable and an irreversible process. The quality and viability of chilli seeds are subjected to variations during storage conditions and it has been found that the life span of seeds depends on moisture content of the seeds, relative humidity, temperature, light and oxygen content under which the seeds are stored. It has been found in the present study that it is possible to extend the shelf life of chilli seeds upto 24 months without deterioration in quality parameters and mineral contents by storing them under vacuum package. Since seed is an important input in agriculture which determines not only the production but also the productivity, it is essential to maintain the quality as well as seed vigour.

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Post harvest processing and scope for mechanization in spices

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Spices are high value export oriented crops extensively used for flavoring food and beverages, medicines, cosmetics, perfumery etc. During the year 2010-11, spices export from India has registered an all time high both in terms of quantity and value. In 2010-11 the export of spices from India has been 525,750 tonnes valued Rs.6840.71 crores as against 502,750 tonnes valued Rs.5560.50 crores in 2009-10, registering an increase of 28% in terms of value and 5% in volume. India commands a formidable position in the World Spice Trade with 48% share in volume and 44% in value. This includes apart from whole dry spices, other value added products like essential oils, oleoresins, curry powder etc. The primary processing in spices which includes, washing, threshing, blanching, drying, cleaning, grading and packaging is very important as the quality of the processed product begins from the quality of raw materials. The post harvest processing and mechanization in major spice crops and tree spices including nutmeg, cinnamon are discussed.

Black pepper

Black pepper, the king of spices, is the whole dried fruit of the vine *Piper nigrum*. Black pepper is widely used as a condiment due to its characteristics aroma, pungency and biting taste. Black pepper is used directly as spice or it serves as raw material for the preparation of its derivatives namely essential oil, oleoresin, curry powder etc. Two primary products of *P. nigrum* that are internationally traded are black pepper and white pepper.

Harvesting

The pepper vines commence to yield from the second year and attain full bearing from fifth year onwards. The plants start flowering during May -June with the onset of south west monsoon and takes about 7-8 months after flowering to reach full maturity. In India the crop is harvested during December – January in plains and January-April in the high ranges of Western Ghats. It is important to harvest pepper at the proper stage of maturity in order to achieve a dried product of good colour and appearance. Harvest starts when one or two berries turn yellow (Purseglove *et al*., 1981). The spikes are nipped of by hand and collected in bags. Normally, single pole bamboo ladder is used as a support for harvesting. Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity required at harvest for processing into different pepper products is given in Table 1.

Table 1 Optimum maturity at harvest for different pepper products

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

Post harvest processing

Black pepper spikes after harvest are subject to post harvest processing operations like threshing, blanching, drying, cleaning and grading before they are packed and stored. Care should be taken to maintain the vital quality of the intrinsic constituents through each step of processing.

Threshing

The berries are separated from the spike usually by trampling with human legs. This operation is crude, tedious and unhygienic. Chances of extraneous matter, soil particles and filth contaminating the produce are also high. Mechanical threshers with capacities varying from 50 kg/h to 1200 kg//h are available which can thresh quickly and provide cleaner products. A comparison of black pepper threshers developed by different agencies is shown in Table 2. Considering the shortage of human labour mechanical threshing can be popularized at cluster level. A local farmer at Wyanad has developed a pepper thresher of capacity 700 kg/h. It consists of a metal drum with rubber lining rotated by a one hp motor and the threshing efficiency was 99 per cent. The damage caused to the berries was negligible.

Table 2. Comparison of black pepper threshers developed by different agencies

Parameter	Model/ make of thresher									
	Gudalur thresher	KAU thresher	TNAU thresher (Improved model)	Malaysian thresher	Indonesian thresher		Vivega thresher		Mohta thresher	Cafex thresher
					Manual	Power	Manual	Power		
Capacity (kg h^{-1})	600	50	200	600	170 – 185	425 – 450	50	200	1200	600
Power source	2 hp motor	0.5 hp motor	1 hp motor	NK	Pedal operated	3 hp motor	Hand operated	3 hp motor	3 hp and 1 hp motor	3 hp motor
Threshing mechanism	Wooden cylinder with aluminium angles	Metal drum with rubber lining	Metal drum with rubber lined rasp bar	Metal drum lined with rubber blades	Metal drum	Metal drum	Metal drum with angles	Metal drum with angles	Metal drum	Metal drum
Max. efficiency (%)	99.5	98.0	99.6	99.8	94.13	92.21	91.5	96.0	Nearly 100	98.0
No. of passes	2 - 3	2 - 3	2	2	NK	NK	3	2	1 - 2	2
Damage (%)	< 0.3	< 0.5	Negligible	NK	3.78	6.13	4.0	> 4.0	Negligible	< 0.5

NK – Not known

Source: Amala dhas and Korikanthimath (2003)

Blanching

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

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

Blanching is known to activate the phenolase enzyme which is responsible for producing the black colour. It also ruptures the cells and thereby accelerates the escape of moisture from the inner core and simultaneously enhances the black colour with the help of resinoids inside the berry. Hence blanched pepper will have more shining black colour and it dries at a faster rate.

Drying

Pepper has moisture content of 60 to 70 per cent at harvest, which should be brought to safer levels of 10-12 per cent by adequate drying. The green colour of matured pepper is due to the presence of chlorophyll pigment. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on concrete floor and dried under sun for 3-5 days to bring the moisture content below 10 per cent. In order to achieve a quality dry product, pepper berries are spread on clean dry concrete floor / bamboo mats/ PVC sheets and dried in the sun for a period of 4 - 6 days. The average dry recovery varies between 33-37 per cent depending on the varieties and cultivars. Solar tunnel drying of pepper in a cylindrical tunnel shaped drying chamber of size 2 x 3 m to a height of 2 m for drying 100 kg pepper was reported by Thirupathi and Visvanathan (2008). Mechanical driers are sometimes used to dry black pepper. Natural convection reverse air flow mechanical drier developed by Regional Research Laboratory, Trivandrum are used by the farmers and cottage scale industrial units for drying of black pepper. Models of varying capacities operated either electrically or by burning agricultural wastes can be used for drying of black pepper also. An electrically operated black pepper drier of 100 kg capacity has been developed by TNAU, Coimbatore. The unit consists of a blower, heating chamber and a drying chamber. The air in the heating chamber is heated by 3 numbers of electrical heaters each of 500 W (Sreenarayanan *et al*., 2003).

Cleaning and grading

The dried pepper is cleaned to get rid of the extraneous matter such as dirt, stalks, leaves etc. Magnetic separator is used to remove metallic contamination such as iron fillings and stray nails. Vibratory conveyors with inclined decks in combination with air classification are used for efficient de-stoning of spices. The ungarbled black pepper contains pinheads, immature pepper and large berries. Broken pepper and light pepper grades are separated pneumatically; pin heads which come along with garbled pepper are separated by sieving. Cleaning on a small scale is done by winnowing and hand picking which removes most of the impurities. Such unit consists of a fan/ blower and a feeding assembly. The fan is placed at the rear end of the hopper. Cleaning is achieved by feeding the material through the hopper into a stream of air blowing in perpendicular direction. The lighter fractions (dust, immature berries, pin heads and spent spikes) are blown away. Grading of black pepper is done by using sieves and sifting black pepper into different grades based on size. TNAU has developed a hand operated cleaner cum grader suitable for cleaning and grading operations (Thirupathi and Visvanathan, 2008). Four inclined outlets are provided for collection of impurities, cleaned and graded products. The unit is provided with three sieves with round holes of size, 3.5 mm, 3.8 mm and 4.8 mm diameters, which are the sieves as per the Agmark specifications. At an operating speed of 25 rpm, the unit had a maximum effectiveness of 66.4 per cent and capacity of 430 kg/h.

Packaging and storage

Pepper is hygroscopic in nature and its nature of absorbing moisture during rainy season result in mould attack and insect infestation as it has good amount of starch. Mould and insect damage can lead to loss of aroma, caking and hydrolytic rancidity. Whole pepper is generally packed and transported in gunny bags and polyethylene lined double burlap bags. Dried pepper having a moisture level of 10-11 per cent can be stored without ant mould growth in jute gunny bags with polyethylene lining or in laminated paper bags. The bags are arranged one over the other on wooden pallets after laying polypropylene sheets.

Cardamom

Cardamom is the dried fruit of the perennial herb, *Elettaria cardamomum*. Cardamom plant starts bearing in 2-3 years after planting. As the flowering continues over a long period, cardamom capsules ripen successively at intervals over an extended period necessitating several pickings. Harvesting should be taken up only at a time when the seeds inside the capsules have become black in colour or reached the maturity stage.

Immediately after harvesting on each day, the capsules are to be pooled and brought to the drying kilns. The capsules are treated with 2 per cent washing soda (Sodium Carbonate) for 10 minutes which enables to retain green colour and prevent growth of mould. In bigger estates two RCC tanks are constructed side by side, one for initial washing of capsules to get rid of dirt / soil and the other for washing with washing soda. After washing, capsules are spread in a single layer on portable drying trays for draining of water. Later the trays are arranged in kilns for drying.

Curing

Cardamom curing or drying is the process in which the moisture content of green cardamom is reduced from 80 percent to 8- 12 percent at an optimum drying temperature of 50 ^{o}C so as to retain its green colour to maximum extend. There are mainly two types of drying *viz.* sun drying and artificial drying by using fire wood fuel or electrical current. In sun drying it is not possible to obtain very good green colour and splitting of capsules is also more. Sun drying requires 5-6 days or more depending up on the availability of sun light. Artificial drying can be done either by electrical or conventional flue pipe drier.

Cross flow electrical dryer

This type of driers is installed by Cardamom Board at central locations to facilitate drying of cardamom by small farmers. These are tray type cross flow dryers and the capacity of these driers varies from 25 to 400 kg. The air is heated by 15 kW air heaters and circulated over the material by fan operated by 0.5 hp motor. The temperature of the drying air is kept at 40 ^{o}C. At full loading capacity, the drying time required is about 18 to 20 h. After completing the drying at 50 ^{o}C, the dryer is run at 60 ^{o}C for easy removal of stalk. The trays are then cooled for 1 h and the stalks are removed by wire mesh cleaner (Patil, 1987).

Kiln drier or flue pipe dryer

The pipe curing method of drying is one of the best methods of drying from which high quality green cardamom can be obtained. The structure usually consists of walls made of bricks or stones and tiled roof with ceiling. A furnace is situated on one side of the chamber; heat is produced by burning firewood from farm waste in the furnace. A pipe made of iron or zinc sheet starting from the furnace passes through the chamber and opens outside the roof. The heated air current generated in the furnace passes through the pipe and increases the temperature of the room. The fans located on either sides of the wall uniformly spread the temperature. Inside the room wooden/ aluminium trays are to be piled one over the other with spacing of 20 to 22.5 cm between the trays. The fire in the furnace has to be regulated so as to maintain 45-50 ^{o}C. Under theses conditions, high quality green cardamom can be prepared in 18-22 hours. A drying chamber of the dimension 4.5m length and 4.5m breadth is sufficient for a plantation producing 1800 to 2000 kg of raw cardamom (Patil, 1987).

Garbling

The dried cardamom is then subjected to garbling. Traditionally this is achieved by rubbing the cardamom capsules against coir mat or wire mesh and winnowed to remove any foreign matter. An oscillatory type semi mechanical garbling unit developed by Tamil Nadu Agricultural University, Coimbatore consists of a concave, oscillating unit, perforated bottom and outlet for flower stalks and cardamom and handle is available to reduce the drudgery of farm workers. The capacity of the unit is 2-3 kg per batch. The rotary type garbler consists of a feed hopper, rotting drum, discharge chute and handle. It takes about 2-3 minutes to garble one batch of about 5 kg. Its capacity is 100kg/h and the efficiency was 98 per cent (Sreenarayanan *et al*., 2003).

The partly cleaned cardamom by garbling requires to be further cleaned to remove the impurities and grade according to size. Grading and standards for large cardamom capsules are based on maturity, extraneous matter, colour and odour. Cleaning of cardamom by removing the discoloured ones, split capsules and other impurities is done by manual method. The grading of dried capsules as per AGMARK specifications is done using round sieves. Mostly sieves with 7mm round holes are used for grading cardamom. They are then stored in black polythene lined gunny bags to retain the green colour.

Ginger

Ginger, the rhizome of *Zingiber officinale* is mainly used as spice condiments either in fresh or in the form of dried ginger. It is an important commercial crop grown for its aromatic rhizomes which are used both as spice and medicine.. Harvesting of the crop for market as for “green ginger” starts in the month from September onwards based on the demand and price of the produce. However for making dried ginger, the crop is harvested between 250-260 days i.e. when the leaves start drying and turn yellow. In India, domestic market prefers fresh green ginger for culinary use while two types of dried ginger i.e. bleached and unbleached are also produced for export purpose. The fresh ginger immediately after harvest is subjected to washing, which is performed to remove dirt, spray residues and other foreign materials.

Peeling

After washing the ginger rhizomes are subjected to peeling operation. Peeling hastens the process of drying and maintains the epidermal cells of the rhizomes which contain the essential oil responsible for aroma of ginger. Indigenously, peeling of ginger is done by scrapping with sharpened bamboo stick. The scrapped or peeled rhizomes are again washed well and dried in sun for a week or more and then rubbed again to give a polish. A mechanical brush type ginger peeling machine has been developed by Rajasthan Agricultural University. The machine essentially consists of two continuous vertical abrasive belts with brush of 32 gauge steel wires, 2.00 cm long and spacing of 1.90 cm. The peeling zone has a length of 135cm and width of 30cm. The peeling efficiency of the machine was 85 per cent and the capacity was 200 kg/h (Agarwal *et al.,* 1987).

Drying

The moisture content of ginger after harvest is about 80-93 per cent (which is brought down to below 10 per cent or even less for its storage. Indigenously ginger is sun dried in a single layer in open yard which takes 7-10 days for complete drying. The sun dried ginger is brown in colour, more or less irregular wrinkled surface and when broken, shows a dark brownish colour. However, it is reported that the quality of dry ginger cured in the bright sun is better than the quality of ginger cured in a closed oven with artificial heat.

Polishing

Polishing of dried ginger is done to remove the wrinkles developed during drying process. In the indigenous method the dried ginger is rubbed against a hard surface. However, hand or power operated polishers similar to turmeric polishers are also employed for the purpose of polishing dried ginger. In case of hand operated polishers an output of 5-6 quintals per day of 8 hours is obtained with the help of two persons. The dried ginger rhizomes are manually graded. For the production of ginger powder, the dried ginger is pulverized with the help of conventional power operated hammer mill. The machines of various capacities to pulverize dried ginger from 25 kg per batch to continuous powdering of 2-3 tonnes / day for large scale production are available.

Turmeric

Turmeric is the dried rhizome of the herbaceous plant *Curcuma longa*. Turmeric, one of the most important cash crops in India is mainly used as a condiment. It is also used for the preparation of dyes and for medicinal purposes. A major portion of the production of turmeric in India is consumed within the country. There is also demand for good quality turmeric in foreign markets; the quality depends upon its appearance, weight, length and thickness, intensity of colour of the core and aroma.

Maturity of the crop is indicated by complete drying up of the plants including the base of the stem. The leaves and stem are cut close to the ground. Two days earlier to digging out the rhizomes, irrigation is given. In case of ridge method of planting, plough is used to lift the rhizomes; otherwise the rhizomes are dug out with manual labour. The harvested rhizomes have to be cured within 2-3 days after harvest for securing maximum out turn. In the turmeric growing regions of Tamil Nadu, mechanical harvesting of turmeric is being practiced. Tamil Nadu Agricultural University (TNAU), Coimbatore has developed a power tiller operated mechanical turmeric harvester with a capacity to harvest 0.6 ha per day (TNAU, 2009a). Tractor drawn turmeric harvester mounted on 35 - 45 hp tractor with a capacity to harvest 1.6 ha per day have been developed by TNAU (TNAU, 2009b). The unit is 120 cm wide and consists of a blade with five bar points for easy penetration into the soil.

Post harvest operations

The harvested turmeric rhizomes before entering into the market is converted into a stable commodity through a number of post harvest curing processes like boiling, drying, polishing and colouring. Curing of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter take a little longer to cook.

The recommended practice is to use pure water for boiling turmeric rhizomes in mild steel or galvanized iron pans. The whole mass is boiled till the fingers become soft, which can be tested by piercing a wooden needle. The needle will pass through the fingers with out much resistance. Generally, it takes about 60-90 minutes. The cooked fingers are heaped on a cleaned drying floor and left undisturbed for 4-5 hours.

Tamil Nadu Agricultural University (TNAU), Coimbatore, (India) has developed an improved turmeric boiler using steam boiling technique (Viswanathan *et al.,* 2002). It consists of a trough, inner perforated drums and lid. The outer drum is made of 18 SWG thick mild steel to a size of 122 x 122 x 55 cm. Four numbers of inner drums of 48 x 48 x 45 cm size are provided in the outer drum to hold turmeric. After placing the turmeric boiler in the furnace, about 75 litres of water is added (6-8 cm depth). During the boiling process, it takes about 25 minutes after production of steam to boil the initial batch of rhizomes and 15-20 minutes for the subsequent batches. The capacity of the boiler is about 200 - 300 kg per batch and 40 q per day of 8 hours. Fuel requirement is 70 – 75 kg of agricultural waste materials. The use of large scale steamer for boiling large quantities of turmeric rhizomes at farm level has been reported (Visvanathan, 2008).

Drying

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on bamboo mat or on the drying floor. It may take 10-15 days for the rhizome to become completely dry. The spheres and fingers are dried separately as the former takes more time to dry.

Polishing

Dried turmeric has poor appearance and rough dull outer surface with scales and root bits. The appearance is improved by smoothening and polishing the outer surface by manual or mechanical rubbing. Polishing is done till the recommended polish of 7-8 per cent is achieved. Usually 5 to 8 per cent of the weight of turmeric is the polishing wastage during full polishing and 2 to 3 per cent during half polishing. Polishing of dried turmeric also helps in removing the wrinkles. Manual polishing consists of rubbing the dried turmeric fingers on a hard surface or trampling them under feet wrapped in gunny bags. Manual polishing gives rough appearance and dull colour in the dried rhizome. A mechanical polisher for turmeric has been developed in the Agricultural University at Andhra Pradesh, India (Sukumaran and Satyanarayana, 1999). The unit consists of 88 cm diameter mild steel drum with meshes and is operated by a 2 hp electrical motor. The drum speed was maintained at 30-32 rpm and the capacity of the polisher is about 600-700 kg/h. A pedal operated hexagonal drum having six polishing plates of size 30 x 60 cm has been developed at OUAT (Pal *et al*., 2008). The capacity of the polisher is 100 kg/h and 6 per cent polishing is achieved.

Cleaning, grading, packing and storage

Turmeric of commerce is described in three ways- fingers, bulbs, and splits. Very little grading of the spice is done at the growers end. A sifter, destoner, and an air screen separator helps to remove materials such as stones, dead insects, excreta, and other extraneous matter. Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light.

Chillies

Chilli (*Capsicum annum)* is the most widely cultivated crop among the spices grown in India. Chillies are harvested when the pods are well ripened and partially wither at the plant itself. At this stage they would have superior pungency and colour.

Drying is the most important post harvest operation of chillies. It is harvested in a ripe condition at moisture content of 70-80 per cent. The ripe chillies need to be dried for 13-15 days for the reduction of moisture to a safe moisture content of 10 percent and then stored.

The traditional method of drying is by spreading out freshly harvested chillies on hard dry ground under the sun. In view of direct exposure to environment, dirt and dust may get deposited on the chillies and this involves excessive handling. The time taken for drying in this case is also long and fading of colour during storage is yet another drawback making the produce less attractive.

Improved drying involves drying of chillies on materials like tarpaulins, cement concrete floor, polythene sheets etc. In mechanical drying, the chillies are dried at a drying temperature of 50^{o} C and at air velocity of 1.5 m/s. Solar cabinet driers developed by CIAE Bhopal with a capacity of 30-50 kg/batch (dry weight basis) can dry chillies in 3-5 days. Waste fired driers developed by PKV Akola is suitable for drying 200 kg of red fresh chillies per batch with in a period of 16 hours for moisture reduction from 73 per cent to 16.6 per cent (Kachru and Gupta, 1993). The cleaning and grading are done manually. Pulverizing of chillies is done in hammer mills of various capacities. The whole or powdered chillies are stored in double layer poly propylene bags as it is easily subjected to aflatoxin contamination.

Nutmeg and mace

Nutmeg (*Myristica fragrans)* is a tree-spice yielding two commercial spice products namely nutmeg and mace. Fruits of nutmeg are harvested when they split open on ripening. The split fruits are either plucked from the tree with a hook or collected soon after they drop onto the ground.

Since this crop is harvested during rainy season in Kerala, sun drying is difficult resulting in improper drying of nutmeg and mace. Drying of medium to large quantities of nutmeg is done in drying rooms. The harvested nutmeg is spread on raised wire mesh floor and heated air is passed through pipes inside the drying room. Continuous drying of nutmeg is not recommended as the oil oozes out with out proper drying. The local practice of drying nutmeg at Kalady, a prominent nutmeg growing area is to pass the hot air for one or two days (8 hours each) and then allow to dry at ambient conditions for one week. This helps in the quick removal of surface moisture from the shell and during tempering there is a slow movement of moisture from the core to the surface with out loss of oil. The heated air is again passed for a day or two and then dried for a week or 10 days. The nutmegs are dried until the seeds inside rattle on shaking. This takes about 15 days or more. The seed cover is removed by breaking the hard seed coat manually or mechanically. Some of the nutmegs are dried improperly by this process have lot of fungal infections and the problems of aflatoxins are also reported by the exporters. Nutmeg samples dried in solar tunnel drier showed a higher reduction in drying time. It took about 8 hours for drying from an initial moisture content of 42.6 per cent to 7.2 per cent while the conventional drying practice took about 13 days (Joy *et al.,* 2000).

Nutmeg is usually packed in double layered jute or polythene bags. If other packing materials are used, care must be taken to avoid materials, which might lead to 'sweating' and mould development. Powered nutmeg is prepared is prepared by grinding at ambient temperature.

Mace is detached from the nut carefully soon after harvest, washed, flattened by hand or between boards and then sun dried until they become brittle. Hot air ovens can be used for drying and the colour retention is much better than sun dried mace. Studies conducted at IISR, Calicut showed that blanching of mace in hot water at 75 ^{o}C for two minutes preserved the qualities of mace during drying (Amaladhas *et al.,* 2002). Dried mace is graded and packed.

Cinnamon

The name cinnamon refers to the tropical evergreen tree as well as the bark that is extracted from the plant belonging to the genus *Cinnamomum*. Both bark and leaves are aromatic. Cinnamon spice is obtained by drying the central part of the bark and is marketed as quills or powder.

Harvesting for bark is made after the second or third year of planting and the subsequent harvest is made between 12 to 18 months after previous harvest. Quills of 60-125 kg/ha are obtained from the first harvest. Plants with the age of 10-12 years will give about 225-300 kg quills per hectare. Cutting of the tree is normally done in the wet season from central portions of shoots. The finest quality of bark is obtained from shoots of uniform brown colour, thin bark 1.0-1.2m length and 1.25 cm diameter. The ideal time for cutting the stem is when the red flush of the young leaves turn to green and this is the indication of free flow of sap between the bark and the wood. Shoots ready for peeling are removed from the stumps and the terminal ends of shoots are also removed. The harvesting season varies from May to November, although harvesting on a limited scale continues through out the year.

Production of quills

Following are the stages in the production of quills:

- *Peeling:* The rough outer bark is first scraped off with a special knife. Then the scraped portion is polished with a brass rod to facilitate easy peeling. A longitudinal slit is made from one end to other and the bark is peeled off. A shoot cut in the morning is peeled on the same day.

- *Rolling:* The barks are packed together and placed one above the other and pressed well. The bark slips are reduced to 20 cm length and are piled up in small enclosures made by sticks. Then they are covered with dry leaves or mat to preserve the moisture for the next day's operation and also to enhance slight fermentation. The retention of moisture is important for the next operation 'piping'.
- *Piping:* Rolled slips are taken to the piping yard for piping operations. The outer skin is scraped off with a small curved knife. The scraped slips are sorted into different grades according to thickness. The graded slips are trimmed; ends are cut and pressed over pipes. Slips are rolled into pipes and soon after they are allowed to dry. During drying, smaller quills are inserted into the bigger ones, forming smooth and pale brown compound quills, which are known as pipes. The quills are arranged in parallel lines in the shade for drying, as direct exposure to the sun at this stage would result in warping. The dried quills, thus obtained, consist of a mixture of coarse and fine types and are yellowish brown in colour. The quills are bleached, if necessary, by sulphur treatment for about 8 hours.

The process of producing quills has several by-products, which are used in further processing:

- *Quillings:* These are broken pieces of quills used mainly for grinding but also for distillation of oil. The pieces vary considerably in size, being about 5 to 15 or 20 cm in length and about 10-25 mm in diameter.
- *Feathering*: These are short shavings and small pieces of leftovers in the processing of the inner bark into quills. Collectively, featherings present a shade darker colour than the quills and a shade lighter than the chips.
- *Chips:* These are small pieces of bark, grayish brown on the outer side and a lighter brown on the inside. They are deficient in both aroma and taste and are not to be compared to the quills for flavour.

Conclusion

Spices and its derivatives offer great scope under food related Agriculture Industries. We expect a huge jump in the export of value added products in the coming decade**.** Post harvest processing and management of spices have great scope considering the present International trade scenario**.** Improved and more scientific methods need to be popularized to get good quality product. Mechanisation in processing operations from harvest till the final stage of packaging is to be standardized to obtain high value produce so as to compete in the international market.

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Exploiting nutraceuticals in spices

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Foods providing health benefits - nutraceuticals, functional or health foods have become trendy since the 1990s, in view of its medicinal synergy, economical status and largely low side effects (Raskin et al., 2002), encouraging greater research funding in this area. Spices are a rich source of valuable phytochemicals, secondary metabolites, possessing potent clinical activities - chemopreventive, anti-oxidant, antimicrobial, anti-inflammatory, aiding digestion, used to treat stomach upset, diarrhea and nausea and to improve storage and preservation of food etc.

Black pepper (*Piper nigrum* Linn.)

Black pepper is used as a spice and medicine, as food preservative, and in perfumery. In Ayurveda, pepper and its derivatives are associated with increased digestive power, improved appetite, cures for throat disease, intermittent fever, cold, cough, dysentery, worms and useful in treatment of toothache, inflammation, leucoderma and epileptic fits. In Chinese medicine, it is used externally for snake and scorpion bites.

Black pepper inhibits drug metabolizing enzymes leading to enhanced drug bioavailability, increase of body's thermogenic activity which directly relate to the processes of releasing energy in cells, offers potent chemopreventive effect against procarcinogens, has analgesic and diuretic effects, is non-genotoxic, antimutagenic (Srinivasan, 2007), antioxidant activity (Kapoor et al., 2009), antimicrobial activity (Nain et al., 2009).

Piperine has bioavailability-enhancing activity with various structurally and therapeutically diverse drugs, attributed to its ability to increase absorption (Khajuria et al., 2002). Piperine protects against hepatotoxicity (Koul and Kapil, 1993). Piperine has anti-depression like activity, cognition enhancing effect, and may help improve brain function (Wattanathorn et al., 2008). Piperine is an anti-obesity factor, can be used to treat type-2 diabetes; it inhibits cholesterol esterification in liver (Rho et al., 2007). Several natural piper amides and extracts of black pepper have antibacterial, antifungal, antiviral and insecticidal activities.

Ginger (*Zingiber officinale* Rosc.)

Ginger has been traditionally used in Ayurvedic, Chinese and Tibb-Unani herbal medicines for treatment of inflammation and oxidative stress, to aid digestion and treat stomach upset, diarrhoea, nausea and as anti-emetic principles, antipyretic, cardiotonic, anticonvulsive or analgesic (Kawai *et al*., 1994).

Antioxidant and anti-inflammatory effects of ginger are attributed to [6]-, [8]-, and [10]-gingerols, 6-Shogaol and citral. Anti-cancer properties of ginger was attributed to [6]-gingerol and [6]-paradol, shogaols, zingerone etc. Anti-ulcer principles from ginger rhizome, 6-gingesulfonic acid, and 3-monoacyl digalactosyl glycerols, ginger glycolipids A, B and C, were reported by Yoshikawa et al. (1994). Saponins, flavonoids, amines, alkaloids and terpenoids from ginger had hypotensive, vasodilator and cardio-suppressant and stimulant effects (Ghayur *et al.,* 2005). Shogaols that protect human neuroblastoma and normal human umbilical vein endothelial cells from ß-amyloid insult were isolated from ginger rhizomes (Kim *et al*., 2002). The essential oil of ginger showed antimicrobial activity against several Gram-positive and Gram-negative bacteria, yeasts and filamentous fungi, and *Salmonella typhi* (Chaisawadi *et al.,* 2005), and larvicide and repellent activity against filarial vector *Culex quinquefasciatus (*Pushpanathan *et al.,* 2008).

Turmeric *(Curcuma longa* L.)

Turmeric, apart from its culinary appeal and common use as spice, is well known for its medicinal properties in Egyptian and Indian culture for more than 6000 years. Curcuminoids are the yellow pigments isolated from turmeric. Its immunomodulatory properties include anti-oxidant, anti-inflammatory and anti-tumor properties (Gao *et al*., 2004). Turmeric and curcumin and tetrahydrocurcumin (THC), have antidiabetic, high antioxidant, antiinflammatory and anticancer properties (Murugan and Pari, 2007). Turmeric's antioxidant property is responsible for blocking Alzheimer's disease (Koo *et al*., 2004). Hepatotoxicity was ameliorated by the curcuminoids; curcumin increased basal bile flow, biliary bilirubin excretion and biliary cholesterol excretion (Deters *et al*., 2000). Curcumin reduced plasma LDL, has hypolipidemic and anti-atherosclerotic effects (Dou *et al*., 2008). Garlic and turmeric are potent vasorelaxants and they reduce the atherogenic properties of cholesterol (Ashraf *et al*., 2005). Dried ground turmeric and ginger rhizomes prevent bone loss in rheumatoid arthritis (Wright *et al*., 2008). Turmeric essential oil had marked antimicrobial activity against Gram negative bacteria and pathogenic fungi (Banerjee and Nigam, 1978).

Oral toxicity indicated significant changes in heart and lungs weights, fall in WBC and RBC levels, gain in weights of sexual organs and increased sperm motility and sperm counts without any spermatotoxic effects (Qureshi *et al*., 1992). The medicinal properties of curcumin from turmeric cannot yet be utilised because of its poor bioavailability, rapid metabolism in the liver and intestinal wall and rapid systemic elimination. Concomitant administration of piperine enhances the serum concentration, extent of absorption and bioavailability of curcumin (Shoba *et al*., 1998).

Small cardamom *(Elettaria cardamomum* Maton.)

Small cardamom oil is an ingredient in food, perfumery, health foods, medicine and beverages. The seeds are also chewed to sweeten the breath. It is used as an aromatic flavoring agent, carminative and stimulant and is traditionally used in various gastrointestinal, cardiovascular, pulmonary, urinary tract and neuronal disorders; kidney stones, anorexia, and general debility (Chempakam and Sindhu, 2008).

Cardamom reduces blood pressure, enhances fibrinolysis and improves antioxidant status, without significantly altering blood lipids and fibrinogen levels in stage 1 hypertensive individuals (Verma *et al*., 2009). It also exhibited highly cytotoxic, anti-inflammatory and anticarcinogenic activities against human tumour cell lines (El Bastawesy and Mohamed, 2005). Extracts of cardamom seeds displayed variable degrees of antimicrobial activity on *Mycobacterium smegmatis, Klebsiella pneumoniae, Staphylococcus aureus, E. coli, Enterococcus faecalis, Micrococcus luteus, Candida albicans*, *Colletotrichum gloeosporioides* and *Fusarium oxysporum* (Sekine *et al*., 2007).

Large cardamom *(Amomum subulatum* Roxb.)

Large cardamom is known to be antiseptic, expectorant (pulmonary), antispasmodic, tonic-nervous stimulant (neuromuscular), cephalic, cardiotonic, diuretic, emmenagogue, sialogogue, digestive (stomachic, carminative), aphrodisiac, anthelminthic, antibacterial. In India, it is used to treat infections of teeth and gums, throat infection, congestion of the lungs and pulmonary tuberculosis, inflammation of eyelids and also digestive disorders. Its essential oils and petroleum ether soluble fractions inhibited gastric lesions (Jamal *et al*., 2005). Large cardamom powder showed contact toxicity and complete inhibition of progeny production against cowpea weevil *Callosobruchus maculatus* F. and rust red flour beetle *Tribolium castaneum* Herbst (Tripathi *et al.*, 2009).

Cinnamon (*Cinnamomum verum***)**

Cinnamon bark is widely used as a spice; the bark oil and leaf oil are used in perfumes, soaps and toothpastes and also as a flavouring agent for liquors and in dentifrices. The leaf oil is also used as a source of eugenol for the production of synthetic vanillin and isoeugenol. Cinnamon and cassia have a broad spectrum of medicinal and pharmacological application. Cinnamon is used as an ingredient in many 'Ayurvedic' and 'Unani' medicinal preparations. The bark of *C. zeylanicum* is an aphrodisiac, anthelmintic and tonic. It is useful in the treatment of biliousness, parched mouth, bronchitis, diarrhoea, itching, heart diseases and urinary diseases. The bark is a carminative and expectorant; used to treat hydrocele, flatulence, headache, piles etc. (Kirtikar & Basu, 1984).

Cinnamon and its essential oil are used as food preservatives since ancient times, due to its antioxidant property. Cinnamon phenolic compounds such as hydroxycinnamaldehyde and hydroxycinnamic acid, are peroxide radicals scavengers and prevent oxidative damages (Wu *et al.,* 1994). Cinnamon is anti-inflammatory, cinnamaldehyde or sodium cinnamate produced hypothermic and antipyretic effects (Chinese Materia Medica), hypotensive effect, mainly due to vasodilation of peripheral vessels and analgesic effects in mice (Wang, 1985).

2-Hydroxycinnamaldehyde and 2-benzyloxy cinnamaldehyde isolated from the stem bark of cinnamon possessed immunomodulatory effects (Koh *et al.,* 1999). In Ayurveda and folklore medicines cinnamon is used in the treatment of diabetes, reducing blood glucose levels in non-insulin dependent diabetics. Cinnamaldehyde is identified as the antidiabetic agent (Lee, 2002).

Cinnamaldehyde, cinnamic acid, cinnamyl alcohol and eugenol possessed antibacterial effects against gram positive bacteria, *Bacillus cereus, Micrococcus luteus, Staphylococcus aureus, S. epidermidis* and *Enterococcus faecalis*; gram negative bacteria *Alcaligenes faecalis, Enterobacter cloacae, Escherichia coli, Klebsiella pneumoniae, Salmonella* sp., *Vibrio parahaemolyticus* and *Pseudomonas aeruginosa*; fungi *Aspergillus niger* and *Rhizopus oligosporus* and yeast *Candida albicans* (Chang *et al*., 2001) and influenza virus (Mancini *et al.,* 1999).

Cassia (*Cinnamomum aromaticum*)

The bark of *C. cassia* and its essential oil are used in various medicinal preparations, as a tonic, stomachic and carminative, antiinflammatory, anticancerous and antitumour activities, effective against headache and piles. The essential oil from stem bark and cinnamaldehyde regulate the triggering of hepatic drug-metabolizing enzymes by glutathione-conjugate formation (Choi *et al.,* 2001). Aqueous extract of cassia bark prevented stress–induced ulcers, the active principles were identified as 3-(2-hydroxy phenyl)-propanoic acid and its *O*-glucoside by Tanaka *et al.* (1989) and cassioside, cinnamoside and 3,4,5-trimethoxyphenol-β-D-apiofuranosyl-(1→6)-β-D-glucopyranoside. 2'-hydroxycinnamaldehyde from cassia stem bark inhibited the initiation of tumour formation (Kwon *et al.,* 1996). Cassia oil was highly toxic to the adult beetles, *Lasioderma serricorne* (Kim-Soon *et al.,* 2003).

Clove (*Syzygium aromaticum* L.)

India's traditional Ayurveda and Chinese medicine healers have used cloves to treat respiratory and digestive ailments. It helps relax smooth muscle lining of the digestive tract and is said to be an aphrodisiac. Medieval German herbalists used cloves as part of anti-gout mixture. Clove paste was applied on the forehead for relief from colds; it has powerful local antiseptic and mild anesthetic actions. Cloves are more often used to assist the action of other herbal remedies rather than alone. When not available, allspice is substituted. Clove and its oil is spicy, warming, stimulant, anodyne, anesthetic (topical), anti-emetic, anti-griping (added to other herbs), vermifuge, uterine stimulant, stomachic, flatulence, colic, aromatic, carminative, antiseptic, antiviral, antibacterial, antifungal, antispasmodic, expectorant, aphrodisiac, promotes salivation and digestive juices; oil is expectorant, emmenogogue; affects kidney, spleen, stomach and has preservative properties and is also used to prepare microscopic slides. Tea made from clove bud (other herbs/spices can be used or added to cloves such as allspice, bay, cinnamon and marjoram) is used to relieve bronchitis, asthma, coughs, susceptibility to infection, tuberculosis, altitude sickness, nervous stomach, nausea, diarrhea, flatulence, indigestion, dyspepsia, gastroenteritis.

Clove essential oil and eugenol has the highest anti-oxidant capability of any essential oil, perhaps one of the highest known for a food or supplement, and therefore it has been included in some 'longevity' formulae and is comparable with the activities of synthetic antioxidants, BHA and pyrogallol, and natural antioxidant α-tocopherol (Lee and Shibamoto, 2001). Clove contains eugenol, β-caryophyllene and several flavonoids, including kaempferol and rhamnetin, which contribute to clove's anti-inflammatory and antioxidant properties (Ghelardini *et al*., 2001). Clove oil is commonly used for numbing tooth pain, and healing mouth and gum sores, and is an active ingredient in several mouthwash products and a number of over-the-counter toothache pain-relief preparations, and is used to disinfect root canals. Eugenol alleviates neuropathic pain and has marked antipyretic activity (Guénette *et al*., 2007). Eugenol and acetyl eugenol were more potent than aspirin in inhibiting platelet aggregation (Srivastava, 1990). It is used in germicides and perfumes, in vanillin synthesis, and as a sweetener or intensifier. The sesquiterpenes, β-cayophyllene, β-cayophyllene epoxide, α-humulene, α-humulene epoxide and eugenol present in clove oil showed potential anticarcinogenic activity by inducing the detoxifying enzyme, glutathione-S-transferase (Zheng *et al.,* 1992).

Clove has excellent antimicrobial and antifungal properties against rye bread spoilage fungi, and thus serves as a remarkable food preservative, it exhibited potent antimicrobial activity against *Bacillus subtilis*, *Escherichia coli* and *Saccharomyces cerevisiae*, *Aspergillus niger, Mycoderma sp., Lactobacillus acidophilus, B. cereus, Fusarium verticilloides, Listeria monocytogenes* in chicken frankfurters and *Rhizoctonia solani* (Mytle *et al*., 2006).

As for toxicity, cloves can cause local skin irritation, pulmonary edema, mouth sensitivity, and sudden lower airway closure; smoking clove cigarettes can damage soft tissues and injure airway linings (Fetrow and Avila, 1999). The use of this herb should be avoided in pregnant and lactating women.

Nutmeg and mace (*Myristica fragrans*)

Nutmeg and mace is more commonly used in Oriental than in Western medicine, for its stimulative and carminative properties. The seeds and oil are carminative, stomachic, astringent, deodorant, narcotic, aphrodisiac and useful against flatulence, nausea, and vomiting, dyspepsia, halitosis, inflammation of the bladder and urinary tract, insomnia and skin diseases; it is also used externally as a stimulant and ointment as a counterirritant. Powdered nutmeg is rarely administered alone, but along with numerous medicines as aromatic adjuncts. Nutmeg essential oil is used in aromatherapy. The main aroma constituents of nutmeg and mace - myristicin, elemicin and isoelemicin – are good stress relievers, but possess narcotic properties with psychotropic effects. Nutmeg has hypolipidemic effect (Ram *et al*., 1996). The antioxidant activity is mainly due to the presence of diarylnonanoid, malabaricone C (Patro *et al.,* 2005). Nutmeg essential oil possesses excellent anticarcinogenic activity (Banerjee *et al.,* 1994). Nutmeg and mace showed potent antibacterial activity against Gram-positive and Gram-negative bacteria, antifungal, insecticidal, antiamoebic and nematicidal properties (Cho *et al*., 2007). Myristicin is neurotoxic to human neuroblastoma cells (Lee *et al*., 2005).

Vanilla (*Vanilla planifolia***)**

From the time of the Aztecs, vanilla was considered an aphrodisiac, a reputation reinforced in 1762 when a German study found that a medication based on vanilla extract cured impotence. Vanilla is also believed to be a febrifuge, i.e., used to reduce fevers, though it is rarely used for any medicinal purposes other than as a pharmaceutical flavoring. Essential oil of vanilla and vanillin is sometimes used in aromatherapy. Vanillin is an antioxidant in complex foods containing polyunsaturated fatty acids (Burri *et al*., 1989), and suppresses chromosomal damage (Keshava *et al*., 1998).

Vanillin displays antioxidant and antimicrobial properties, against both Gram-positive and Gram-negative food-spoilage bacteria, yeasts and moulds in fruit purées and laboratory growth media (Fitzgerald *et al*., 2003), and hence has the potential for use as a food preservative.

To conclude, every spice is a veritable source of nutraceutical. It is of immense importance that we take full advantage of this native, tropical crop for medicinal uses, as has been done in our traditional systems of medicine. To validate this traditional wisdom using the latest technology, identifying and characterizing the bioactive principles, studying the mode of their action, and developing drugs based on these phytochemicals has enormous potential in our quest for ever more safer and effective medicines.

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Micro encapsulation in spices

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India is well known as a land of spices from times immemorial. No other country in the world grows as many kinds of spices as India. Export of spices and spice products from India during 2011, registered a rise of 21 per cent compared to last year. Spice oils and oleoresins exports increased in terms of value (Spices Board, 2011). There is a continuing and expanding international demand for herbs, spices and essential oils. Social changes, including food diversification, the desire for new flavours, increasing importance of “ethnic” food and the increased importance of processed food, which requires condiments and aromatic herbs for its preparation, are driving an increase in this demand. Developing countries have a significant opportunity to benefit from this increasing demand. Many of the products can be sold in a dried form or as extracts (e.g. essential oils), which gives them a high value per unit weight.

Fairly recent developments in extraction technology have led to the increased use of spice oleoresins as opposed to the spices themselves. An oleoresin consists of the total soluble components that are extracted from a particular spice by a solvent. Spice oils and oleoresin find their application in food and fragrance industries. These are sensitive materials which can easily suffer degradation under the action of oxygen, light and moderate temperature. However, processing conditions of these materials can cause reduction in its functional properties. Furthermore, they are insoluble in water, and for certain applications a controlled release is required. Therefore an adequate formulation of the essential oil which takes into account these aspects is required for commercial applications. Common goals in the development of essential oil formulations are to protect the essential oil from degradation or from losses by evaporation, to achieve a controlled release, and to facilitate handling. Microcapsules of biopolymers loaded with essential oils meet these requirements.

Microencapsulation

Microencapsulation may be defined as the process of surrounding or enveloping one substance within another substance on a very small scale, yielding capsules ranging from less than one micron to several hundred microns in size. Microcapsules may be spherically shaped, with a continuous wall surrounding the core, while others are asymmetrically and variably shaped, with a quantity of smaller droplets of core material embedded throughout the microcapsule. All three states of matter (solids, liquids, and gases) may be microencapsulated. This allows liquid and gas phase materials to be handled more easily as solids.

When milled spices are stored, their essential oils evaporate over time. Micro-encapsulation preserves these valuable flavours. In this process, which takes just a few seconds, the milled particles are microencapsulated and then sterilized at a mild temperature to reduce the germ count. The process is suitable for a variety of spices.

Method of microencapsulation

Microencapsulation processes are usually categorized into two groups chemical processes and mechanical or physical processes. These labels can, however, be somewhat misleading, as some processes classified as mechanical might involve or even rely upon a chemical reaction, and some chemical techniques rely solely on physical events. A clearer indication as to which category an encapsulation method belongs is whether or not the capsules are produced in a tank or reactor containing liquid, as in chemical processes, as opposed to mechanical or physical processes, which employ a gas phase as part of the encapsulation and rely chiefly on commercially available devices and equipment to generate microcapsules.

Chemical methods

Capsules for carbonless paper and for many other applications are produced by a chemical technique called complex coacervation. This method of encapsulation takes advantage of the reaction of aqueous solutions of cationic and anionic polymers such as gelatin and gum arabic. The polymers form a concentrated phase called the complex coacervate. The coacervate exists in equilibrium with a dilute supernatant phase. As water-immiscible core material is introduced into the system, thin films of the polymer coacervate coat the dispersed droplets of core material. The thin films are then solidified to make the capsules harvestable.

Interfacial polymerization (IFP) is another chemical method of microencapsulation. This technique is characterized by wall formation via the rapid polymerization of monomers at the surface of the droplets or particles of dispersed core material. A multifunctional monomer is dissolved in the core material, and this solution is dispersed in an aqueous phase. A reactant to the monomer is added to the aqueous phase, and polymerization quickly ensues at the surfaces of the core droplets, forming the capsule walls. IFP can be used to prepare bigger microcapsules, but most commercial IFP processes produce smaller capsules in the 20-30 micron diameter range for herbicides and pesticide uses, or even smaller 3-6 micron diameter range for carbonless paper ink.

Polymer-polymer incompatibility, also called phase separation, is generally grouped with other chemical encapsulation techniques, despite the fact that usually no actual chemical reaction is involved in the process. This method utilizes two polymers that are soluble in a common solvent, yet do not mix with one another in the solution. The polymers form two separate phases, one rich in the polymer intended to form the capsule walls, the other rich in the incompatible polymer meant to induce the separation of the two phases. The second polymer is not intended to be part of the finished microcapsule wall, although some may be caught inside the capsule shell and remain as an impurity.

In situ polymerization is a chemical encapsulation technique very similar to interfacial polymerization. The distinguishing characteristic of in situ polymerization is that no reactants are included in the core material. All polymerization occurs in the continuous phase, rather than on both sides of the interface between the continuous phase and the core material, as in IFP. Examples of this method include urea-formaldehyde (UF) and melamine formaldehyde (MF) encapsulation systems.

Centrifugal force processes were developed in the 1940s to encapsulate fish oils and vitamins, protecting them from oxidation. In this method an oil and water emulsion is extruded through small holes in a cup rotating within an oil bath. The aqueous portion of the emulsion is rich in a water-soluble polymer, such as gelatin, that gels when cooled. The resulting droplets are cooled to form gelled polymer-matrix beads containing dispersed droplets of oil that are dried to isolate.

Similar in concept to centrifugal force processes, submerged nozzle processes produce microcapsules when the oil core material is extruded with gelatin through a two-fluid nozzle. The oil droplets are enveloped in gelatin as they are extruded through the nozzle. Then the capsules are cooled to gel the walls, before being collected and dried.

Physical methods

Spray drying is a mechanical microencapsulation method developed in the 1930s. An emulsion is prepared by dispersing the core material, usually an oil or active ingredient immiscible with water; into a concentrated solution of wall material until the desired size of oil droplets are attained. The resultant emulsion is atomized into a spray of droplets by pumping the slurry through a rotating disc into the heated compartment of a spray drier. There the water portion of the emulsion is evaporated, yielding dried capsules of variable shape containing scattered drops of core material. The capsules are collected through continuous discharge from the spray drying chamber. This method can also be used to dry small microencapsulated materials from an aqueous slurry that are produced by chemical methods.

Fluid bed coating, another mechanical encapsulation method, is restricted to encapsulation of solid core materials, including liquids absorbed into porous solids. This technique is used extensively to encapsulate pharmaceuticals. Solid particles to be encapsulated are suspended on a jet of air and then covered by a spray of liquid coating material. The capsules are then moved to an area where their shells are solidified by cooling or solvent vaporization.

The process of suspending, spraying, and cooling is repeated until the capsules' walls are of the desired thickness. This process is known as the Wurster process when the spray nozzle is located at the bottom of the fluidized bed of particles. Both fluidized bed coating and the Wurster process are variations of the pan coating method. In pan coating, solid particles are mixed with a dry coating material and the temperature is raised so that the coating material melts and encloses the core particles, and then is solidified by cooling; or, the coating material can be gradually applied to core particles tumbling in a vessel rather than being wholly mixed with the core particles from the start of encapsulation.

Centrifugal extrusion processes generally produce capsules of a larger size, from 250 microns up to a few millimeters in diameter. The core and the shell materials, which should be immiscible with one another, are pushed through a spinning two-fluid nozzle. This movement forms an unbroken rope which naturally splits into round droplets directly after clearing the nozzle. The continuous walls of these droplets are solidified either by cooling or by a gelling bath, depending on the composition and properties of the coating material.

Another mechanical encapsulation process is rotational suspension separation, or the spinning disk method. The internal phase is dispersed into the liquid wall material and the mixture is advanced onto a turning disk. Droplets of pure shell material are thrown off from the rim of the disk along with discrete particles of core material enclosed in a skin of shell material. After having been solidified by cooling, the microcapsules are collected separately from the particles of shell material.

Progress in microencapsulation of spices

Microencapsulation of black pepper oleoresin

Despite solvent extracted spice oleoresin having many advantages over ground spices, its sensitivity to light, heat and oxygen is a disadvantage. One approach to overcome this is microencapsulation. According to Shaikh *et al*., 2006 microencapsulation of black pepper oleoresin done by spray-drying, using gum arabic and modified starch as wall materials. The microcapsules were evaluated for the content and stability of volatiles, non-volatiles, total piperine and entrapped piperine for six weeks. Gum arabic offered greater protection to the pepper oleoresin than modified starch.

Encapsulated cardamom oil

The retention and shelf stability of cardamom oil entrapped in freeze- and spray-dried microcapsules coated with skim milk powder and modified starch was investigated by Najafi *et al.*, 2011. It was found that the retention of flavor in freeze-dried matrices was low and independent from the composition of wall material, whereas for the spray-dried microcapsules, it was much higher and markedly dependent on the type and percentage of coating material. It was also shown that the particle size of spray-dried powder greatly contributed to the flavor retention and surface oil content of microcapsules. Additionally, microscopic observation of powder particles revealed that the type of wall material and drying method distinctly influenced the morphological characteristics of powders which presumably caused a difference in their capability of cardamom oil retention.

Microencapsulation of curcumin pigments

Curcumin has strong coloring power, safety and innocuity, comprehensive pharmacological function, but its low stability and water insoluble nature limit its application. Curcumin microcapsules were prepared by spray-drying process using porous starch and gelatin as wall material here. Results showed optimal condition as follows: the ratio of core and wall material of 1/30, embedding temperature of 70 °C, embedding time 2 h, inlet gas temperature of 190 °C, feed flow rate 70 ml/min and drying air flow 70 m^3 /h, at which the microencapsules had good encapsulation efficiency. The stability of microencapsulation curcumin against light, heat, pH was effectively improved and its solubility was increased greatly. This study would be helpful to the industrial application of curcumin. (Wang *et al.,* 2009)

Ginger oil microencapsulation

The flavour of ginger is typically due to its essential oils characterized by warm, spicy, and woody notes, with slight lemon flavour. Ginger essential oil finds its application in food and fragrance industries. However, processing conditions can cause degradation of ginger essential oil reducing its functional properties which could be prevented by microencapsulation. In present investigation, efforts were made to prepare ginger oil from dry ginger by hydro distillation method and its physico-chemical properties were observed. Further, systematic efforts were taken to standardize the spray drying condition for preparation of microencapsulated ginger oil powder by using acacia gum as wall material. The observations related to physico-chemical and organoleptic characteristics of prepared powders revealed that the inlet temperature of 160°C is optimum in microencapsulation of ginger oil. (Kadam e*t al.*, 2011)

Microencapsulation of cinnamon leaf oil and garlic oil

Cinnamon leaf oil (CLO) and garlic oils (GO) are good antimicrobials, however, their volatility complicates their application as food preservatives. Hence, microencapsulation of CLO and GO with b-cyclodextrin (b-CD) was studied at 4:96, 8:92, 12:88, and 16:84 (oil:b-CD) percent weight ratios. Microcapsule characterization included gas chromatography analysis, moisture sorption–desorption isotherms, infrared spectroscopy (IR), and antifungal activity against *Alternaria alternata*. Major oil constituents were eugenol for CLO and allyl disulfide for GO. The 16:84 ratio (CLO:b-CD) showed the highest eugenol content; the allyl disulfide content was higher, but not significantly different P(0.05) for the 12:88 and 16:84 ratios. Microcapsules showed lower moisture sorption than b-CD, although during water desorption there were no difference between them. Hydrogen bonds were detected between oil constituents and b-CD by IR spectroscopy. CLO:b-CD and GO:b-CD microcapsules displayed good antifungal activity against *Alternaria alternata*. Therefore, CLO and GO microcapsules can have important applications in the food industry as stable natural antimicrobial compound systems. (Ayala-Zavala *et al.*, 2008)

Advantages

- Conversion from liquid to free flowing powders
- Protection from environment (oxygen, light, moisture and heat)
- Prevent reaction with other substances
- Enhance or alter surface properties of the materials
- Improve or enhance nutrition
- Reduce material toxicity
- Decrease evaporation or transfer rate of core (oils)
- Promote ease of handling of core
- Control the release of core until the right stimulus
- Mask the taste of bitter compounds
- Promote uniform dispersion of core and improves shelf-life

Conclusion

Micro encapsulation of spice oils and oleoresins are value added products and can be kept for a long time. There is vast scope for this kind of products in future. Research thrust can be given for microencapsulation of other spice oils.

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COCO (A) NUTMEG - Growing money on trees

(Current scenario in nutmeg production and challenges ahead)

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In the event of global climatic changes in Caribbean countries especially in Grenada, there has been shortage in production of nutmeg. The demand for nutmeg on the other hand is increasing due to value addition and utilization in food processing, oleoresin and pharmaceutical applications. India is emerging as a major producer of nutmeg. Even though nutmeg is a humid tropical tree spice crop grown under rainfed conditions in Srilanka, Caribbean, Indonesia and other countries, Tamil Nadu, especially in the western parts viz., Pollachi, the crop is successfully cultivated as a mixed crop in coconut plantation under irrigation and fertigation.

The major advantage of this geographical location is that the quality of nutmeg is superior due to the aflatoxin free product. The characteristics of nutmeg depend heavily on the environment in which it is grown. The nutmeg plantations in India including Kerala are mostly seedling progenies and clonal plantations raised through orthotropic shoots. The major problems faced in these plantations are tall headedness added with very shallow root system, prone to uprooting of trees due to high rains coupled with wind.

Moreover, the handling operations including harvesting, foliar spraying are tedious due to non-availability of work force to carry out these farm operations, and hence it is very difficult to maintain the plantation in future in case the prices drop due to over production.

More over, the availably of quality planting material (Orthotropic budded plants) has become the major constraint. To address these problems, it is vital to switch over to improved methods like High Density Planting, planting vegetatively propagated plants using plagiotropic shoots used as scion, following scientific canopy management to get higher output. The Indian Institute of Spices Research, Calicut has successfully standardized epicotyl grafting in nutmeg which can be effectively utilized for the high density planting. This method standardized for the first time by IISR using epicotyle grafting is advantageous as large number of plants can be propagated from a single mother plant under one roof. Propagation through plagiotropic shoots, more number of grafted plants can be obtained from a single tree when compared to the orthotropic shoot multiplication.

The advantages foreseen in improved methods as suggested are easy cultivation operations like picking, foliar spray, convenience in regulating the fruit set and development through which more fruits of higher grade can be obtained. Pruning facilitates sun light to penetrate inside the canopy inducing photosynthesis for better harvest.

Under the HDP system, there is scope for planting nutmeg under trelly system also, which allows easy operations like hand harvesting and other farm operations. Such system is in practice in plantation crops like cocoa in countries like Australia.

Scientific interventions are required for standardizing the HDP which includes canopy management for optimized sunlight, nutrients and moisture. The nutmeg production warrants the need to improve the productivity. The farmers require quality planting materials who are now being exploited by private nurseries who supply inferior planting material without any pedigree. The prices of nutmeg may seem to be attractive today but in the event of over production and fall in prices, the farmers should make their mind to accept the loss, however the income from nutmeg is an additional income other than coconut. Under mixed cropping involving coconut and nutmeg, the per unit land is effectively utilized and higher returns are achieved.

Development programmes for spice crops

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India is considered as the largest producer, consumer and exporter of spices in the world. Even in the distant past, people from other parts of the world came to India in search of spices. In fact, some historians say that we lost our independence, due to these intrusions. That is no longer true. We welcome the steady improvement in communications and an expanding world market. Indian spices are relished by the people of 150 countries around the world and it can add considerably to better understanding and to mutual advantage.

Spices Board, India, under the Ministry of Commerce and Industry, is the apex organization for promoting Indian spices and spice products worldwide. The Board was constituted on 26th February, 1987 as per the Spices Board Act, 1986 by merging the erstwhile Cardamom Board and Spices Export Promotion Council. The mandate of the Board is mainly for export development and promotion of 52 scheduled spices. The Board is responsible for the over all development, research, domestic marketing of both small and large cardamom. It has also the responsibility for post harvest improvement as an export enhancing measure with respect to all the spices in the schedule.

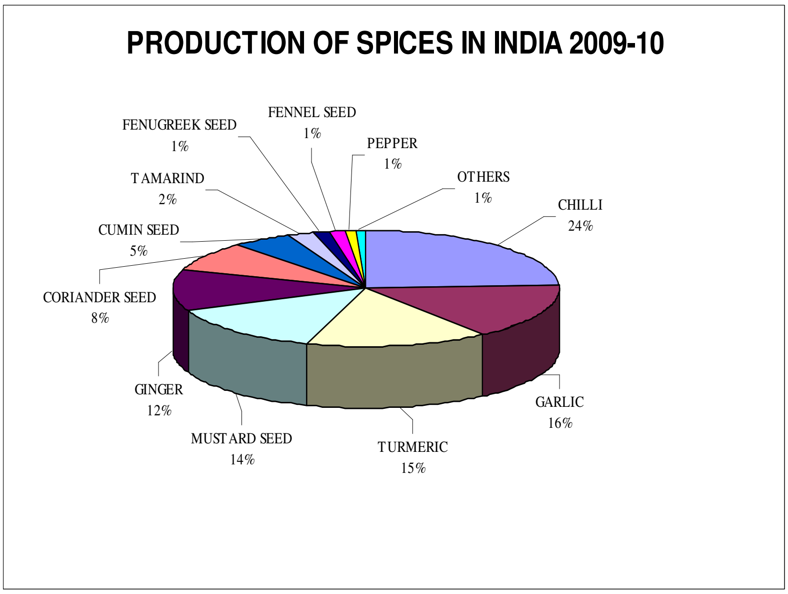
The soil and climatic conditions in some parts of India are ideal for cultivation of spices, particularly pepper, cardamom, chillies, mint, ginger, turmeric and other spices. With the entry of more countries in spice production and trade, the position of India in the world market is becoming more competitive. Therefore, it becomes imperative to raise the productivity level of spices to make available the commodities at competitive prices and also to improve the quality of the produce adopting the latest technology.

The average production of spices in India is over 61.18 lakh tons and area under cultivation of spices is approximately 37.11 lakh hectare.

Table 1. Spice wise area and production (2009-10)

Spice name	Area in hectares	Production in tons
Chilli	809699	1470351.9
Garlic	189390	968236.4
Turmeric	187535	927911.6
Mustard seed	822250	828919
Ginger	142089	708255.6
Coriander seed	537650	504844
Cumin seed	517133	303943
Tamarind	44186	125524
Fenugreek seed	72039	88972
Fennel seed	53497	83576
Pepper	198986	55565.45
Ajwan seed	25690	11348
Nutmeg	16001	11271.71
Dill seed	8537	10447

Cardamom (small)	71110	10075
Celery seed	4312	5248
Cardamom(large)	6150	2492.66
Cloves	2081	763.82
Cinnamon	150	30.6
Saffron	2691	4.86
TOTAL	**3711176**	**6117780**



The estimated world demand for spices is 1.10 million tons valued $3.48 billion during 2010-11. With the exports of 0.53 million tons valued US$ 1.50 billion, the share of India in the world spice trade is 48% in quantity and 43% in value.

As per the latest figures available from the Economics and Statistics Department, Ministry of Agriculture, the estimated domestic production of spices in the country is over 5 million tons. Only 10% of this production is exported. Because of the upwardly mobile middle class population in the country and their changing food habits, the domestic consumption of spices has increased considerably in recent years.

Export of spices

Spices exports from India has continued its upward trend and reached an all time high both in quantity and value in 2010-11. During the year, a total volume of 5,25,750 tons of spices and spice products valued ₹ 6840.71 crore (US$1500.00 Million) have been exported from India, which is an increase of 5 per cent in volume, value wise 23 per cent and 28 per cent in rupee and dollar respectively.

In the current year, April – September 2011, spices export has been 2,37,585 tons valued ₹ 4165.59 crores (US$ 920.55 million) which is higher by 29% in rupee value compared to the export performance of 2,94,925 tons valued ₹ 3220.16 crores (US$ 699.25 million) in the same period of last year.

Table 2. Export of spices from India during 2010-11 and April-September 2011-12

Spices	2010-11			2011-12(April-Sept)		
	Quantity (tons)	Value (₹ crores)	Mln in US$	Quantity (tons)	Value (₹ Crores)	Mln in US$
Pepper	18850	383.18	84.18	11250	311.52	68.84
Cardamom(small)	1175	132.16	29.04	1825	161.00	35.58
Cardamom (large)	775	44.63	9.80	280	22.68	5.01
Chilli	240000	1535.54	337.35	83000	815.25	180.17
Ginger	15750	121.31	26.65	8000	90.02	19.89
Turmeric	49250	702.85	154.41	41500	450.76	99.61
Coriander	40500	166.63	36.61	13500	80.06	17.69
Cumin	32500	395.98	86.99	16000	222.61	49.20
Celery	3750	25.86	5.68	1750	11.43	2.52
Fennel	7250	65.88	14.47	3500	34.18	7.55
Fenugreek	18500	65.48	14.39	10000	32.15	7.10
Other seeds (1)	12500	55.58	12.21	5400	28.70	6.34
Garlic	17300	69.77	15.33	1010	5.98	1.32
Nutmeg & mace	2100	97.77	21.48	1370	86.73	19.17
Other spices (2)	25250	160.15	35.19	20000	147.98	32.70
Curry powders/paste	15250	210.51	46.25	8000	115.53	25.53
Mint products	17450	1696.79	372.77	7650	940.39	207.82
Spice oils & oleoresins	7600	910.62	200.06	3550	608.62	134.50
Total	525750	6840.71	1502.85	237585	4165.59	920.55
(1) include mustard, aniseed, bishops weed (ajwainseed), dill seed, poppy seed etc.						
(2) include vanilla, tamarind, asafetida, cassia, saffron etc.						
(3) include mint oils, menthol & menthol crystals						

Table 3. Major contributors in 2010-11

Major spices	**Value**		**Volume**	
	(₹ crores)	**(%)**	**(MT)**	**(%)**
Mint products	1,696.79	25%	17,450	35
Chilli	1,535.54	22%	2,40,000	46%
Spice oils & oleoresins	910.62	13%	7,600	1%
Turmeric	702.85	10%	49,250	9%
Cumin	395.98	6%	32,500	6%
Pepper	383.19	6%	18,850	4%
Curry powder/paste	210.51	3%	15,250	3%
Other spices	200.65	3%	30,000	6%
Coriander	166.63	2%	40,500	8%
Cardamom small	132.16	2%	1,175	0.2%

Table 4. Export of spices from India

Year	Quantity (tons)	Value (₹ crores)	Value (US$ million)
2005-06	3,50,363	2627.62	592.90
2006-07	3,73,750	3575.75	792.95
2007-08	4,44,250	4435.50	1101.80
2008-09	4,70,520	5300.25	1168.40
2009-10	5,02,750	5560.50	1173.75
2010-11	5,25,750	6840.71	1500.00
2011-12 (Apr.-Sept)	2,37,585	4165.59	920.55

Table 5. Major markets for Indian spices 2010-11

Country	Value		Volume		Major items
	(₹ Crores)	(%)	(MT)	(%)	
U.S.A	1036.29	15.1	44,880	8.5	Mint items, spices oils & oleoresins, pepper, chilii and turmeric
China	662.43	9.7	12,986	2.5	Mint products, chilli, spices oils & oleoresins
Malaysia	487.31	7.1	64,476	12.3	Chilli, turmeric, coriander, cumin, fennel
U.A.E	371.84	5.4	50,385	9.6	Turmeric, chilli, nutmeg, curry powder, cumin
U.K.	349.62	5.1	20,188	3.8	Spices oils & oleoresins, mint products, chilli
Bangladesh	284.48	4.2	56,097	10.7	Chilli, turmeric, garlic, ginger, cumin
Germany	279.16	4.1	6,036	1.1	Spices oils & oleoresins, mint products, turmeric
Pakistan	265.20	3.9	46,806	8.9	Chilli, large cardamom, cumin, coriander
Japan	223.59	3.3	7,800	1.5	Spices oils & oleoresins, mint products, turmeric
Sri Lanka	218.56	3.2	39,170	7.5	Chilli, turmeric, coriander, cumin, fennel
Saudi Arabia	201.31	2.9	12,394	2.4	Small cardamom, curry powder, turmeric, ginger
Singapore	201.16	2.9	6,535	1.2	Spices oils & oleoresins, mint products, chilli
South Africa	138.68	2.0	11,164	2.1	Spices oils & oleoresins, turmeric, chilli, coriander
Netherlands	133.61	2.0	5,229	1.0	Spices oils & oleoresins, mint products, turmeric, pepper, chilli
Mexico	112.57	1.6	9,671	1.8	Spices oils & oleoresins, mint products, cumin, chilli
Brazil	111.49	1.6	4,310	0.8	Spices oils & oleoresins, mint products, cumin, chilli

In 2010-11, Indian spices reached more than 137 countries and 20 countries cover 80% of export value.

Import of spices in 2010-11

The import of spices during 2010-11 was 86775 tons valued at ₹ 1175.51 crores (US$ 257.00 million). During 2011-12, the import of spices upto September 2011 is 48960 tons valued ₹ 932.91 crores (US$ 207.09 million).

Table 6. Item-wise import of spices in to India

	2010-2011 (E)	
Spice	**Qty in tons**	**Value in ₹ lakhs**
Pepper (1)	16,100	27010.63
Cardamom (small)	75	656.53
Cardamom(large)	4050	10217.50
Chilli/paprika	450	408.25
Ginger fresh/dry	21500	8266.75
Turmeric	3900	4220.54
Coriander	915	621.91
Cumin black/white	515	593.30
Mustard seed	820	380.41
Poppy seed	9050	12763.93
Garlic	115	116.10
Clove	7000	15337.03
Nutmeg	1460	5272.28
Mace	400	2559.94
Cassia	11000	5728.52
Star anise	2750	2866.93
Other spices (2)	5470	6037.72
Oils & oleoresins (3)	1205	14492.32
Total	**86775**	**117550.57**
Value in million US $		**257.00**

(1) Includes white pepper, light pepper and black pepper
(2) Includes aniseed, asafoetida, cinnamon, pepper long, cambodge, herbal spices and spices.
(3) Includes spices oils & oleoresins and mint products.
(4) Source : from customs / d g c i & s., calcutta

Development programmes for spices

Spices Board is responsible for the overall development of cardamom (small & large) especially in improving production and productivity. Post Harvest Improvement of spices is also vested with Spices Board. For achieving these objectives, the following schemes are implemented by the Board during XI plan.

1. Special purpose fund for replantation and rejuvenation of cardamom plantations
2. Export oriented production and post harvest improvement of spices
3. Development of spices in North Eastern states
4. Pepper development programme

I. Special purpose fund for replantation and rejuvenation of cardamom plantations (small & large)

The main objective of this scheme is to improve the production of cardamom from 10000 tons to 15000 tons. This scheme addresses the issue of replanting/rejuvenation of the old and uneconomic plantations of cardamom small and large in the States of Kerala, Karnataka, Tamil Nadu, Sikkim and Darjeeling districts of West Bengal.The programmes implemented under the scheme are given below:

Cardamom small

i) Production and supply of quality planting materials

In Karnataka, the planting materials are produced through bed nurseries, poly bag nurseries and sucker nurseries by giving ₹ 1.25 per planting material as subsidy whereas in Kerala it is produced through sucker multiplication nurseries providing ₹ 1.75 per sucker.

ii) Cardamom replanting

This programme is intended to encourage small and marginal growers to take up replantation of old, senile and uneconomic plantations. A per hectare subsidy of ₹ 39,171/- and ₹ 29,675/- is offered to small and marginal growers respectively having cardamom area up to 4 ha. and above 4 – 8 hectares respectively in the States of Kerala and Tamil Nadu. In Karnataka, the per hectare subsidy offered is `29,919/- for holdings up to 4 hectares and ₹ 22,666/- for holdings above 4-8 hectares The subsidy provided for planting material production is deducted from replanting subsidy.

iii) Rejuvenation

Under rejuvenation programme, poor yielding plants in the existing plantations will be identified and removed and the gaps thus formed will be filled with quality planting material and scientific agricultural practices will be followed. This programme is implemented in the States of Kerala and Tamil Nadu only for registered small and marginal growers of cardamom having holdings up to 4 ha. The subsidy provided for rejuvenation is ₹ 14025/- per hectare (subsidy for planting material is deducted from the subsidy for rejuvenation).

Cardamom large (replanting & rejuvenation)

Cardamom large is mainly grown in the sub Himalayan tracts of Sikkim and Darjeeling district of West Bengal. Lack of technical know-how, non availability of quality planting materials, presence of senile, old and uneconomic plants are the major factors affecting large cardamom. Board supports raising of sucker nurseries in farmers' field by offering a subsidy of ₹ 1.15 per sucker. A per hectare subsidy of ₹ 16,500/- and ₹ 12,500/- is offered to small and marginal growers having cardamom area up to 4 hectare and above 4 – 8 hectares respectively. (Subsidy offered for planting material production is deducted from the subsidy for replantation). The rejuvenation programme is same as that for cardamom small and the subsidy offered is ₹ 6600/- per hectare for holding size up to 4 hectares (subsidy for planting material is deducted).

II. Export oriented production and post harvest improvement of spices

The activity components under the scheme are aimed at improving the productivity of cardamom small and large, improving quality of spices at farm level, encouraging organic production of spices and creation of replicable models based on integrated pest management, development of spices with export potential in North Eastern Region, extension service to spice growers etc.

Small cardamom

i) Irrigation and land development

The programme aims at providing water resources in cardamom plantations by constructing water storage devices like farm ponds and wells. Installation of irrigation equipments, soil & water conservation works are also supported. The programme provides financial support to farmers by way of subsidy ranging from 25 to 50% of the unit cost approved by NABARD.

ii) Rainwater harvesting

Irrigation during summer months is very much essential in cardamom plantations for getting a higher yield. A cheap method of harvesting rain water for irrigation purpose in the cardamom plantations is adopted using excavated storage tanks lined with UV resistant polythene tarpaulin also called Silpauline sheets.

It is estimated that a storage tank of 200 cubic metre capacity (eg. 16m x 5m x 2.5m lined with Silpauline) can store about two lakh litres of rain water, which is sufficient to provide 10 – 12 rounds of irrigation in a cardamom plantation of 0.8 hectare. The cost of such a device is estimated to be around ₹ 24,000/- (₹ 16,000/- for excavation work and ₹ 8,000/- for silpauline sheets). Subsidy @ 33.33% of the actual cost, limited to ₹ 8000/- is allowed for the construction of one 200 cubic metre capacity tank to registered small and marginal growers of cardamom.

iii) Improved curing devices for small cardamom

Cardamom is dried in traditional curing houses using firewood as fuel. Sun drying is not popular due to the loss of green colour during the process. Few innovative growers have started installing cardamom curing systems using alternate fuels *viz*., Diesel, LP Gas which gives their produce better colour and cost effective drying. These driers are eco-friendly, labour saving and easy to operate. The drying time is reduced from 28 – 36 hours to about 20 hours in these driers. The programme is aimed at providing 33.3 % of the actual cost of drier as subsidy subject to a maximum of ₹ 60,000/- per device.

Programmes for other spices

i) Seed spices threshers (power operated and manually operated)

The harvesting and post harvest practices followed by some farmers of seed spices are unhygienic which results in contamination of the products with foreign matters like stalks, dirt, sand, stem bits etc.In order to educate the farmers and to avoid contamination in the final product Board introduced threshers which are operated manually as well as with power, for separating the seeds from the dried plants. The cost of such a power and manual thresher are estimated as ₹ 1.00 lakh and ₹ 30,000/- respectively. 50% of the cost subject to a maximum of ₹ 50,000/- for a power thresher and ₹ 15,000/- for a manually operated thresher is being paid as subsidy.

ii) Supply of pepper threshers

The objective of the programme is to assist the pepper growers to acquire threshers to separate pepper berries from spikes under hygienic condition. Pepper growers having a minimum of 500 vines are eligible to avail the scheme. The subsidy offered is ₹ 7,000/- per thresher irrespective of the capacity of the equipment.

iii) Distribution of bamboo mats for pepper

The programme is intended to encourage the small and marginal pepper growers to dry pepper on hygienic bamboo mats coated with paper-fenugreek paste. 90% and 50% of the cost of bamboo mats is offered as subsidy to tribal and general category growers respectively.

iv) Promotion of Integrated Pest Management (IPM) in chilli

Consignments of Indian chillies were detained in the recent past due to reported presence of pesticides. The presence of pesticides has caused serious trade disruptions. Therefore, it is necessary to popularise integrated pest management in chillies for educating farmers on safe and judicious use of pesticides and chemicals. IPM kits containing pheromone traps, bio agents like Trichoderma, Trichogramma, neem based pesticides etc. are supplied at subsidized rate limiting to ₹ 2000/- per hectare.

Post harvest improvement of spices

i) Supply of polythene / silpauline sheets for drying spices

In order to dry spices *viz.*, pepper, chillies and seed spices under hygienic conditions, the Board subsidizes the supply of HDPE / Silpauline sheets at 50% and 33.33% of the cost to tribal and other category of growers respectively.

ii) Training programme for quality improvement of spices

The Board is regularly conducting quality improvement training programmes to farmers, officials of State Agri./Horti. Department, traders, members of NGOs for educating them on scientific methods of pre/post harvest and storage operations and updated quality requirements for major spices.

Promotion of organic farming

In recent years, organic agriculture is gaining momentum all over the world and the world demand for organically produced foods is growing rapidly in developed countries like Europe, USA, Japan and Australia. According to APEDA, duly certified organic farming accounts only for about 1 per cent of overall agricultural production in India compared to 2 percent at the global level. Though the "Go Organic" habit has not caught on yet in the country, the future will see a rise in demand and supply of organic foods. Therefore, early entry into this segment will improve the exportability and demand for Indian spices, which will help the country to withstand competition from low cost countries in south East Asia. In order to promote farmers for organic production of spices, programmes like organic farm certification assistance, support for setting up vermi-compost units, promoting organic cultivation of spices are being implemented during XI Plan.

i) Organic farm certification assistance

The programme aims to help growers/ processors of spices in acquiring organic certification which is a pre-requisite for marketing organic spices. Board is assisting group of farmers, NGOs and Farmers Co-operative Societies/ Associations in acquiring certification for their farms/ processing units by meeting 50% cost of the certification, subject to a maximum of ₹ 75,000/-. Individual farmers and processors are eligible for 50% of the cost of certification subject to a maximum of ₹ 25,000/- per certification.

ii) Support for vermi-compost units

There is need to produce organic inputs in the farm itself to maintain soil fertility and to support organic production. In order to enable the growers to produce organic farm inputs, particularly vermicompost, ₹ 2000/- is offered as grant-in-aid to growers to set up a unit with one ton output of vermicompost.

iii) Organic cultivation of spices

Since the market for organic products is gradually registering an upward trend, there is large scope for promoting organic cultivation of spices in suitable locations. During XI Plan, Board is assisting growers for taking up organic cultivation of spices by giving a subsidy of 12.5% cost of production subject to a maximum of ₹ 5,000/- per hectare.

III. Development of spices in North Eastern states
Large cardamom
i) Curing houses (Modified Bhatti)

The large cardamom growers traditionally cure their cardamom in the locally fabricated bhatties. This does not ensure proper drying and ideal colour in the cured cardamom. Board had introduced and evaluated a number of curing methods using different fuels and has selected a system which gives best quality. In order to popularize this method, Board is providing subsidy @ ₹ 5,000/- for 200 kg capacity and ₹ 9,000/- for 400 kg capacity drier respectively.

ii) Rainwater harvesting: The same scheme for small cardamom is implemented**.**

Other spices

Chilli, ginger and turmeric are extensively cultivated in the North Eastern states. Some of the indigenous varieties *viz*., 'China', 'Nadia', and 'Thingpui' in ginger, `Lakadong' in turmeric and 'birds eye' in chilli are considered rich in oil, curcumin content and capsaicin content respectively. The agro–climatic conditions prevailing in North Eastern States are suitable for the cultivation of pepper and large cardamom and these crops can be profitably grown in these regions to create exportable surplus.

The major constraints noticed in the development of spices in North Eastern region are lack of an organised marketing system and lack of know how on cultivation and post harvest practices. Spices Board therefore, implements an integrated scheme for the development of export oriented spices in North Eastern States with the following components:

- **Organic cultivation of Lakadong turmeric**

Lakadong Turmeric is having high curcumin content (5.5%) and hence suitable for extraction of colour. This variety is highly location specific and is very much preferred by the exporters for extraction of the colour. Hence organic production of Lakadong turmeric in Meghalaya and other North Eastern States was supported during XI Plan period. Availability of quality planting materials is a major limiting factor in its production. So, ₹ 12,500/- per hectare is provided as subsidy towards 50% of the cost of planting material.

- **Organic cultivation of ginger**

Ginger varieties like Nadia and China are having higher oil content and hence suitable for exports. During XI Plan period, to promote production of these varieties organically in North Eastern states ₹ 12,500/- per hectare is provided as subsidy towards 50% cost of the planting materials.

- **Training of officers and farmers of North Eastern States**

Board arranges training programmes for the officers of the State Agri/ Horti. Departments and growers of North Eastern States on the recent advances in the areas of cultivation, harvest and post harvest techniques of spices.

IV. Pepper development programme

Pepper production in Idukki and Waynad districts of Kerala and North East region with the assistance from NHM and Ministry of Commerce & Industry

Pepper production in the last few years has been stagnating around 50000 tons and incidence of foot rot disease has caused extensive damage to pepper vines. The vast majority of farmers is having less than one hectare holdings and is heavily affected by this disease. To address the issue of decline in production and productivity of pepper in major growing tracts like Idukki and Wynad districts of Kerala as well as the North Eastern states, Board had initiated pepper development programmes viz. replantation and rejuvenation of old and uneconomic pepper gardens, planting material production, Integrated disease management, promotion of organic inputs etc. The programme assisted by NHM is being implemented at a total outlay of ₹ 120 crores in Idukki district. In Waynad and North Eastern states region, a similar programme is being implemented with a financial outlay of ₹ 53.28 crores from the Ministry of Commerce. The formal approval of the project from the Ministry of Agriculture and Cooperation, Krishi Bhavan, New Delhi for implementation of pepper project in Karnataka state under NHM is awaited.

Marketing programme of the Board

These programmes are aimed at equipping the exporters to have the necessary competitive edge in sustaining and increasing export market for Indian spices. The programmes focus on quality improvement, value addition and technology transfer/upgradation. The various programmes include adoption of hi-tech and technology upgradation, setting up of quality control laboratory, quality certification, sending business samples abroad, printing promotional literatures / brochures, packaging development and bar coding registration, spice parks etc.

Constraints in spices development

1. Vagaries of climate.
2. Large number of small and marginal holdings.
3. Shortage of skilled labourers
4. Lack of availability of quality planting materials.
5. Inadequate nutrition management.
6. Pest and disease problems.
7. Low productivity.
8. Lack of mechanization in pre and post harvest operations.
9. Lack of primary processing facilities.
10. Lack of quality awareness among the farming community.
11. Market Intermediaries
12. Weak supply chain management.

Proposals for XII plan

In the XII plan, Spices Board is mainly focussing on a sustainable production development, which ensures a stable income for the farmers, increased production and improving quality without disturbing the environmental balance.

Organic farming

Organic spices command considerable attraction from a sizable consumer segment because of the relative safety, these spices offer. Therefore, organic farming makes better sense and we need to expand infrastructure, training facilities manifold besides putting in place attractive financial incentives to farmers for taking up organic farming.

Productivity is a major issue, which needs to be addressed immediately. For a quantum leap in productivity, more attention should be given to produce good quality planting materials using latest techniques in bio-technology and make this available in adequate quantities to the spice growers. Increasing consumer/exporters resistance to pesticide residues, should make our scientists think in terms of evolving varieties to resistant to pest and diseases. Strategies for increasing production should be based on both short term as well as long term programmes. The short term measures are adoption of IPM/IDM/GAP, making available high yielding disease resistant cultivars. As a long term measure it is necessary to enhance the production of spices by extending cultivation to non traditional areas, adoption of spice based inter-cropping systems.

Post harvest technology

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 to12% 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 initiating lot of programmes on these issues to educate growers on post harvest operations through various Board’s programmes and publicity awareness campaigns.

Mechanization

Availability of timely manual labour is a problem in plantation sector, which has resulted in poor maintenance of plantations and thereby reduction in production and quality. Efficient and economical farm implements and machines are major tools of agriculture modernisation, making it remunerative and cost effective. In order to assist farmers to take up timely cultural operations, the Board proposes to popularize mechanization of spices through subsidized supply of plant protection equipments, weed cutters, pit makers, harvesters, threshers and post harvest equipments for washing, cleaning, drying, polishing, grading etc.

Vision of the spice industry

- To become the international processing hub and premier supplier of clean and value added spices and herbs to the industrial, retail and food service segments of the global spices market by meeting the quality requirements.
- To enhance export earnings from US$ 1.5 billion to US$ 3.0 billion by 2017 and further to US$10.00 billion by 2025

Farmer’s right- issues and prospects

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India is predominantly an agricultural country and agriculture contributes about 24.5% of the country’s Gross Domestic Product (GDP). Agriculture provides employment and is main source of livelihood to 65% of the Indian population. Over 600million farmers are involved in agricultural related activities in India. Small and marginal farmers constitute about 67 % of the farming population in the country(Sahay and Shrivasatava,2001).India is also endowed with enormous diversity of many agri-horticultural crops adapted to diverse agro ecological conditions besides strong R&D through National Agricultural Research Systems(NARS). Another important feature of Indian agriculture its large scale dependence on farm saved seeds. In India about 80 % of the farmers relay on farm saved seeds (Economic Survey2005-06).Though the formal seed industry is very active in the country, it is estimated that only 1/10 of the total seed requirements of the farmers are met by this formal sector (Singh et al.1990).And the seed industry’s presence is virtually nonexistent in many vegetatively propagated crops. Globalization has opened up many new challenges, opportunities and threats to Indian Agriculture.

India being a member of the World Trade Organization (WTO) became signatory to the Trade Related Aspects of the Intellectual Property Rights (TRIPS) which provide under Article 27.3(b) that the plant varieties are to be protected either by patents or by an effective *sui generis* system. This obligation culminated in enacting the Plant Varieties and Farmer’s(PPV & FR) Act 2001 and the PPV &FR rules were notified in2003.The objectives set forth in the Act are (i). To provide an effective system for protection of plant varieties and rights of farmers and plant breeders (ii). To recognize and protect the right of farmers in respect of their contribution towards conserving, improving and making available plant genetic resources for development of new plant varieties; (iii) To protect plant breeder’s right to accelerate agricultural development in the country; (iv). To stimulate both the public and private sector to invest in R&D for the development of new plant varieties; (v). Facilitate growth of seed industry to ensure production and availability of high quality seeds and planting material to farmers. Nine rights can be said to have been given to farmers under the Act including: the rights to save, exchange and (to a limited extent) sell seeds and propagating material, to register varieties, to recognition and reward for conservation of varieties, to benefit sharing, to information about expected performance of a variety, compensation for failure of variety to perform, availability of seeds of registered variety, free services for registration, conducting tests on varieties, legal claims under the Act, and protection from infringement. India’s law is unique in that it simultaneously aims to protect both breeders and farmers right as the PPV & FR Act not only upholds farmers’ rights to save, use and exchange seeds and propagating material but also attempts to enable farmers to claim special forms of intellectual property rights over their varieties. The Act grants plant variety protection on new varieties (largely modeled on UPOV), extant varieties and essentially derived varieties. Extant varieties include farmers’ varieties, varieties in the public domain and varieties about which there is common knowledge.

The Act clearly defines Farmers’ variety, new variety, extant variety and essentially derived variety (see Boxes, Table 1). Registration of farmer’s varieties is one of the major mandates of the Act.

Table 1. Varieties protectable under India's PVP& FR Act

Type	Definition	Criteria	Right granted	Duration
New variety	Variety means a plant grouping except microorganism defined by certain characteristics under the Act. It is new if it meets specified criteria	Novelty Distinctness Uniformity Stability	Exclusive right for the breeder to produce, sell, market, distribute, import or export the variety	Initially 9 Years renewable up to total of 18 years for trees and vines Initially 6 Years renewable up to total of 15 for other crops
Extent variety	A variety available in India which is notified under sections 5 of the seeds Act, 1966; or a farmers' variety; or a variety about which there is common knowledge; or any other variety which is in the public domain	Distinctness uniformity stability. As specified under the regulations	Exclusive right to produce, sell, market, distribute, import or export the variety if claimed by the breeder and in cases where not claimed by breeder, the Central Government of State Government shall have the right	15 years from the date of notification of that variety by the Central Government under sections 5 of the seeds Act, 1966
Farmer's variety	A variety which has been traditionally cultivated and evolved by the farmers in their fields; or is a wild relative or land race of a variety about which the farmers possess the common knowledge.	Unclear if Distinctness, uniformity and stability would be the criteria or not	Unclear	Unclear

Essentially derived variety	A variety predominantly derived from such initial variety, or from a variety that itself is predominantly derived from such initial variety, while retaining the expression of the essential characteristics that result from the genotype or combination of genotypes of such initial variety; is clearly distinguishable from such initial variety; and conforms (except for the differences which results from the act of derivation) to such initial variety in the expression of the essential characteristics that result from the genotype or combination of genotype of such initial variety	Genera or species specified by the Central Government and tests determine if it is an EDV	Same rights as a breeder of a new variety provided that the authorization by the breeder of the initial variety to the breeder of essentially derived variety may be subject to terms mutually agreed upon by both the parties	Initially 9 years renewable up to total of 18 years for trees and vines Initially 6 years renewable up to total of 15 for other crops

Source: Adapted from "The Protection of Plant Varieties and Farmers' Rights Act, 2001", Act No. 52 of 2001, New Delhi: Akalank Publications. (cf Ramanna, 2006)

It is now almost since 10 years the Act is *invogue,* though the Authority started to receive the application for registration from 2007 only.So far 39 crop representing 45 species are notified/being processed for registration under the Act (Table 2). Let us examine the achievements made by this new Act (Tables 3&4). The filing trend upto 2010 November indicates (i) Maximum number of applications for extant variety followed by new varieties. (ii)Decrease in filing of extant variety application after 2009 while there is a steady increase in filing application for new varieties over the years. (iii) A spurt in filing of farmer's varieties in 2009 followed by sudden drop in the year 2010. (iv) In total only 55 applications for farmers varieties are filed so far, the least among all the three category.(v).The fear that the research /commercial interest of the private sector will be drifted away from hybrids following the enforcement of PPV & FR Act is unfound as the private sector is still active with respect to new variety though mostly hybrids. In fact the robust trend in filing activity of extant and new varieties suggests that both the private and public sector view the PPV &FR Act useful.

Table 2. Crops notified/being processed for registration under PPV & FR Act

Category	Crop
Cereals	Wheat, rice, maize
Millets	Pearl millet, sorghum
Commercial crops/trees	Cotton(4 species), jute (2 species), sugar cane, casuarina*(2 species), eucalyptus*, neem*, karanj* (*Pongamia pinnata)*
Oil seeds	Sesame, groundnut, soybean ,sunflower, safflower, castor indian mustard (2 species), rapeseed and gobhi sarson (2 species)
Plantation crops	Coconut*, rubber*, tea*, coffee*, cashew*
Spices	Black pepper, cardamom, ginger, turmeric, garlic, coriander*
Pulses	Pigeon pea, chick pea, green gram, black gram, french bean, lentil, field pea, linseed
Tuber crops	Potato, cassava*, sweet potato*
Vegetables	Onion, okra, brinjal, cabbage, cauliflower, tomato, cucurbits* (8 species)
Medicinal plants	Ashwagandha*, mentha*, brahmi*, *rosa damascene**, plantago*
Ornamentals	Rose, orchids*(3 genera), periwinkle*, chrysanthemum
Fruit crops	Apple*, pear*, litchi*, guava*, banana*, papaya*, citrus* (3 species), cherry*, mango, walnut*, almond*, apricot*
Others	Bamboo* (2 species), jatropha*

*Under process for registration (Source: Singh, 2011)

Table 3. Annual trends in filing of applications under PPV & FR Act

Variety/year	2007	2008	2009	2010	Total
Extant Variety	355	389	382	54	1180
Farmers' Variety	2	5	44	4	55
New Variety	69	152	179	273	673
Grand Total	426	546	605	331	1908

Source: Kochu Pillai (2011)

Table 4. Application trends: Public vs. Private sector

Classification	Private	Public	Total
Extant Variety	73	400	473
Farmers' Variety	N/A	N/A	3
New Variety	144	28	172
Grand Total	217	428	648

Source: Kochu Pillai (2011)

Though the Act made impact nationally, the reasons for the low turnout under the famer's variety registration need to be studied. Besides there are other issues which either runs contradictory to the provisions of the Act or negate the very purpose of the Act.

Why the low turn out in registering the famer's varieties?

There can be more than one reason for this trend such as (i) Lack of awareness among the farming community about the Act,and its benefit; (ii).Absence of mechanism to evaluate farmers varieties; (iii) Difficulty in filing the application; (iv) Lack of immediate monetary benefit as against the recognition by other agencies like National Innovation Foundation (The Foundation awarded so far 36 plant variety Awards across a wide variety of crops cutting across many states); (v) Dispute over the owner ship of the variety and concerns of its legal implications. (vi) The criteria for registration of extant varieties and farmers varieties, is not entirely clear in the Act. (vii) The farmer breeders may not be able to generate data required by the Plant Variety Authority eg. HMT paddy variety.

Another disturbing trend in the farmer's variety registration profile is the skewed representation of the crops. Only 6 crop species are represented in this category whereas 20 crops found place in the category of new varieties and extant varieties. Out of the total 55 applications filed for registration under farmer's variety 39 are of rice,6 for bread wheat,5 for kidney beans, 2 each for pigeon pea and chick pea and just one for sorghum a (Kochu Pillai, 2011).A large number of crops are thus virtually left out, so far. Further, whether the farmer's variety profiling is scale and region neutral also needs analysis.One may wish to see the rather low turn out in farmer's variety registration in tandem with the contradictory/contentious issues.

Contradictory issues

- On one side the Govt. encourages seed replacement to mitigate the seed gap while under PPV&FR Act the emphasis is on farm saving and resowing /replanting of all types of seeds and planting material.
- The Patent Amendment Acts could pave the way for further extensions of patentability in agriculture that may restrict farmers' rights to save, use or exchange seeds.
- Geographical Indication Act: The Geographical Indications Act may enable farmers to claim rights for agricultural goods originating in a specific region, or it could restrict access of farmers to the protected goods depending on the way it is implemented(Ramanna,2006).
- Farmers' Rights as a form of intellectual property rights or Farmers' Rights as a development right? Both have merits. While defining Farmers' Rights as a kind of intellectual property rights could provide a negotiating edge at the global level, it may not be of great utility in ensuring rights for farmers in developing countries including livelihood and food security right, social justice and access to resources. Legal and economic costs of establishing the system, the difficulties of legally claiming rights for farmers, and the limited returns from plant variety protection itself are some other reasons to ponder over (Ramanna, 2006).

Anti commons issue: The tragedy of the anticommons refers to the obstacles that arise when a user needs to access multiple protected input to develop a single useful product(Heller and Eisenberg,1998).It occurs when governments grant rights too many people over a resource with no one having an effective privilege of use. India's PPV&FR Act is an attempt to evolve a multiple rights system that could pose several obstacles to useful utilization and exchange of resources (Fig.1).

Overlapping agencies: Many organization are in the forefront of protecting biodiversity, traditional knowledge etc (Table5). Confusion may arise in the minds of farmers about the most appropriate agency to approach.

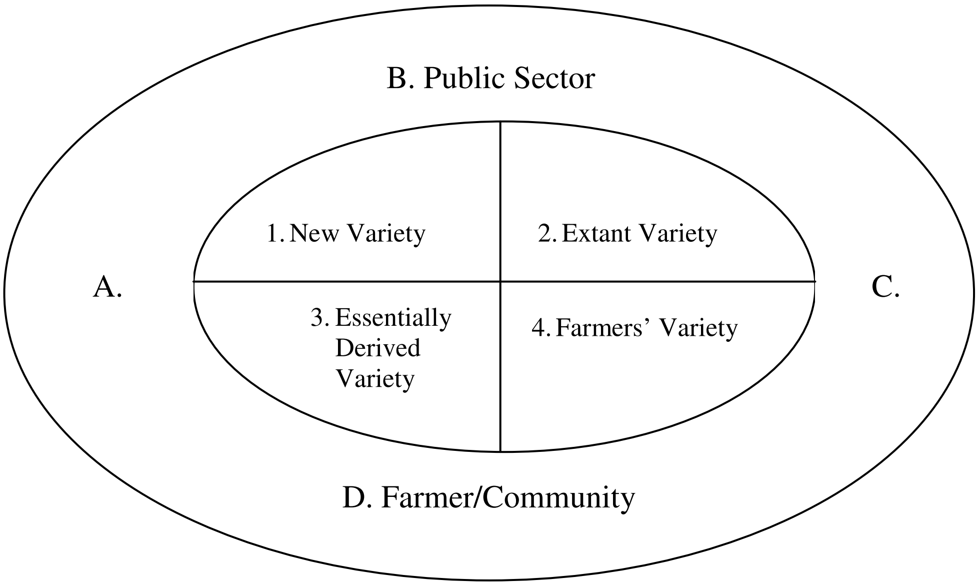

Fig.1. Stakeholders and varietal protection under India's Law (Source: Ramanna, 2006)

Table 5. Agencies involved in documenting genetic resources/traditional knowledge

Activity and year of launch	**Agency**	**Description**
National Biodiversity and Strategy Action Plan, 1999	Ministry of Environment and Forests, UNDP, Kalpraviksh and Biotech Consortium India Limited	Assessment and stocktaking of biodiversity-related information at national, local and state levels
National Innovation Foundation, 2000	Department of Science and Technology and IIM, Ahmedabad	Register and support grass roots innovation
Biodiversity Plan	Government of Karnataka	State laws regarding biodiversity
Biodiversity Plan	Government of Kerala	State laws regarding biodiversity
Mission Mode Project on Collection, documentation and validation of indigenous technical knowledge	Indian Council of Agricultural Research	Documentation and registration of traditional knowledge
Traditional Knowledge Digital Library	Council of Scientific and Industrial Research	International Library on traditional knowledge
People's Biodiversity Registers, 1995	Foundation for Revitalization of Local Health Traditions	Records the status, uses and management of living resources
Honeybee Network, 1996	Sristi	Document innovative practices of farmers/artisans

Database	Swaminathan Foundation	Document contribution of tribal group for securing benefits
Documentation	Research Foundation, Green Foundation, Gene Campaign	Documenting and collecting traditional knowledge/resources
Village Registry, 1997	Pattuvam Village, Kerala	Produced a registry of genetic resources within their village and declared it their property

Source: Compiled from various sources including: www.sristi.org, Gadgil et al, "New Meanings for Old Knowledge: The People's Biodiversity Registers Programme, paper for Ecological Applications; Government of Indian, 2000, National Biodiversity Strategy and Action Plan: Guidelines and Concept Papers; Government of Karnataka, Biodiversity Plan (cf.Ramanna, 2006).

Seed Bill 2004: Though the Act has rather equal stress on plant breeders right and farmer's right, the Seed Bill 2004, now pending to be enacted, favours the former. The National Biodiversity Act, 2002, based on the Convention on Biological Diversity, also regulates access to and use of genetic resources in India (Table 6).

Table 6. Comparative assessment of PPV& FR, Seed Bill and CBD Act.

	PPV & FR 2001	Seeds Bill 2004	Biological Diversity Act 2002
Objective	Create a system to protect rights of plant breeders, and farmers as breeders	Provide quality seeds for sale, and more active import/export of seeds	To conserve biodiversity, its sustainable use, and equitable sharing of the benefits arising out of the use of biological resources and knowledge
Registration	Non-compulsory registration of plant varieties with Plant Varieties Registry	National Seeds Register to compulsorily register all seeds sold, including farm-saved seeds that are sold commercially	National Biodiversity Authority to get records of local biological resources from local biodiversity management committees; to conserve and record
Farmers' rights over resources	Clearly acknowledges farmers' right as entitlements. Disclosure of seed parental lines before registering	Anybody can register any variety and then sell without disclosing its parental lines. Give residual rights to farmers	Farmers explicitly mentioned as benefit 'claimers' if their varieties are commercially exploited
Compensation to farmers	Spurious seeds sellers get 3 months to 1 year in prison. Rs. 50,000-Rs. 5,00,000 fine. Second offence: prison term 1-3 years. Fine: Rs. 2,00,000-Rs. 20,000,000	Spurious seed sellers in prison up to 6 months. Fine: up o Rs. 50,000	Such a situation is out of the purview of this law
Parental line disclosure	Compulsory	Not required	-
Seed price regulation	Yes	No	-
Protection	6-9 years	15-30 years	-

Data base of existing /extant varieties; Though the Act mandates a complete database of all varieties of common knowledge including all registered extant and farmer's varieties and such varieties being cultivated outside India for each crop species prior to grant registration for new varieties belonging to such species, the task is yet to accomplish (Sateesh Kumar *et al.*, 2011).This situation can lead to spurious filing in the absence of provisions to counter check the claim.

Other inconsistencies pointed out include lack of clarity in defining essentially derived variety, varieties of common knowledge, defective application published in the PV journal as Advertisement under section 21 of PPV & FR Act, etc. (Sateesh Kumar *et.al.*, 2011).

Other issues of concern

1. *GM crops*

Biotechnology Policy of the Government which promotes biotechnology for India's agriculture, do not propose any restrictions in Farmers' Rights .However, as on date there is strong views for and against GM crops in India. Proponents of biotechnology assert that genetically modified (GM) crops have the potential to solve India's agricultural problems, while opponents argue that it has negative implications for farmer's livelihoods and biodiversity. But, if farmers want the genetically modified (GM) crops**,** what right does the government have to deny them GM crops? The issue came to limelight after the Gujarat incident involving the GM cotton variety. A powerful rights oriented position of 'GM as farmer's choice' emerged after the Gujarat incident (Ramanna, 2006). It may be noted that Government granted approval to grow this variety, only after it was reported that the BT cotton was under cultivation (illegally) in some districts of Gujarat. Ramanna (2006) suggested that experiences with Bt cotton reflect the individual socio economic conditions and perceptions of the farmer which must be taken note of when arguing that a particular technology is 'farmer's choice'. However, it would be more appropriate if the issue may be viewed akin to the license granted to grow certain crops(for example, narcotic crops, Lathyrus).It will be prudent to grow the GM varieties only after its approval by the competent agency, irrespective of any other considerations.

Another issue to be viewed in tandem with the cultivation of GM crops is the right for organic production. If any farmer wants his field/crop be free from accidental contamination of GM variety, pollen from GM crops, is it his right to have the required minimum isolation distance from the GM field so as to prevent cross pollination, or admixing? This is relevant specially as majority (80%) of the Indian farmers are small or marginal with less than two hectares of land.

2. *Minimum price for the produce*

Securing guaranteed prices for their produce should be part of Farmers' Rights, it is being argued. With the increasing rate of farmer's suicide this view merits attention. Another important issue to be considered in this regard is moratorium for bank loans availed in the event of crop failure or drastic reduction in price.

3. *Right from wild animal damage*

Many wild animals such as elephant, wild boar, deer etc. cause considerable damage to many crops and affect the livelihood of many farmers. As killing these animals is prohibited under the Wild Life Act, and the compensation given is often paltry and late, as a matter of right can farmers claim protection from wild animal damage? This needs discussion.

Box.1

According to the Act a "farmers" means any person who –
(i) Cultivates crops by cultivating the land himself; or
(ii) Cultivates crops by directly supervising the cultivation or land through any other person; or
(iii) Conserves and preserves, severally or jointly, with any other person any wild species or traditional varieties or adds value to such wild species or traditional varieties through selection and identification of their useful properties. [Sec. 2 (k)]

Box-2

"Variety" means a plant grouping except micro organism within a single botanical taxon of the lowest known rank, which can be - [Sec.2(*za*)]

(i) defined by the expression of the characteristics resulting from a given genotype of that plant grouping;
(ii) distinguished from any other plant grouping by expression of at least one of the said characteristics; and
(iii) considered as a unit with regard to its suitability for being propagated, which remains unchanged after such propagation, and includes propagating material of such variety, extant variety, transgenic variety, farmers' variety and essentially derived variety.

"Extant variety" means a variety available in India which is, [Sec. 2(*j*)]

(i) notified under section 5 of the Seeds Act, 1966 or
(ii) farmers variety or
(iii) a variety about which there is common knowledge or
(iv) any other variety which is in public domain.

"Farmers' variety" means a variety which, [Sec. 2(*l*)]

(i) has been traditionally cultivated and evolved by the farmers in their fields or
(ii) is a wild relative or land race or a variety about which the farmers possess the common knowledge

Box-3

"Essentially derived variety" – A variety shall be said to be essentially derived from such initial variety when it – [Sec. 2(*i*)]

(i) is predominantly derived from such initial variety, or from a variety that itself is predominantly derived from such initial variety, while retaining the expression of the essential characteristics that results from the genotype or combination of genotypes of such initial variety
(ii) is clearly distinguishable from such initial variety and
(iii) conforms (except for the differences which result from the act of derivation) to such initial variety in the expression of the essential characteristics that result from the genotype or combination of genotype of such initial variety

"Essential characteristics" means such heritable traits of a plant variety which are determined by the expression of one or more genes of other heritable determinants that contribute to the principal features, performance or value of the plant variety.

Conclusions

The Indian PPV & FR Act is unique in that it simultaneously aims to protect both breeders and farmers right. Achievements made during the last 10 years of its existence are impressive. However, the filing trend of applications for registration reveals, a relatively slow response under farmer's variety as compared to other categories. Information on the benefit accrued from licensing and cross licensing of the registered farmers varieties is not available while the licensing of new varieties is progressing well. In order to claim the farmer's right effectively more farmer's varieties need to be registered. The existing lacunae/ inconsistencies in the Act should be addressed to immediately so as to make the Act more farmer friendly. There must be also provision to address the emerging issues under the aegis of the Act. Scale and region neutrality of the Act are also to be looked into.

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ABSTRACTS
OF
POSTER PRESENTATIONS

Variety and genetic diversity

P-01

Studies on molecular diversity in local genetic resources of nutmeg

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Forty four nutmeg (*Myristica fragrans* Houtt) genotypes, selected from different sources, were studied for understanding the diversity using RAPD marker. Out of 195 RAPD markers, 162 produced by 19 primers showed on an average of 77.47 per cent polymorphism. Jaccard's similarity coefficients observed in the range of 0.54–0.92 indicated only 46 percent dissimilarity at molecular level among the genotypes studied. The genotypes *viz*., Keri-A and Keri-B (Sl. Nos. 10 & 19) and Keri-C, a male genotype formed two extreme ends of the dendrogram, and all other genotypes formed clusters at various levels in between the two, depending on the their relatedness. The genotypes *viz*., N-2/4, 1/5, 2/5 and 4/5 having medium sized fruits and vigorous growth clustered together recording more than 80 per cent genetic relatedness. On the other hand, genotypes such as N-6/2, 7/2, 2/3, 3/3 and ½ (SL. Nos 33-36 and 44) all from the same source, having genes for medium fruit size and dwarf canopy structure, scattered in different clusters in the dendrogram.

P-02

Development of genomic microsatellite markers for small cardamom and their utilization in estimation of genetic diversity in small cardamom germplasm

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Microsatellite markers in small cardamom (*Elettaria cardamomum* Maton) were developed using the hybridization enrichment method. A total of 39 microsatellite repeats (SSR) were found in 27 sequences. Of these, primers could be successfully designed for 11 microsatellites and these were used for studying the diversity of 20 important small cardamom accessions. These SSR markers gave clear profiles for most of the genotypes tested. Data on microsatellite loci were scored, similarity matrix was generated based on Dice similarity coefficient and was subjected to clustering using UPGMA algorithm for dendrogram construction. The dendrogram showed two major clusters one of which was further divided into two sub clusters indicating the inter relationship patterns among the varieties studied. The study showed that the microsatellite markers developed can be used for molecular characterization and for marker assisted selection of small cardamom. This is the first report of isolation, characterization and utilization of genomic microsatellites in small cardamom.

P-03

Cross generic amplification of rice, turmeric and ginger microsatellite (SSR) markers in small cardamom

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In an effort to develop a repository of microsatellite markers for genetic analysis of small cardamom (*Elettaria cardamomum* Maton), the available SSR markers reported from nearest related genera were screened for cross generic amplification. Microsatellite markers were developed or used on related genera like ginger and turmeric. In turmeric, 18 genomic SSRs and 17 EST SSRs and in ginger 8 genomic SSRs were reported. About 12 rice SSR markers which were found to give cross generic amplification in ginger were also used along with one EST-SSR developed by us. These markers totaling 56 were studied for transferability to small cardamom. Of these 4 (33%) rice SSR markers, 1 (12.5%) ginger SSR, 1 ginger EST and 7 (20%) turmeric SSR primers showed repeatable amplification in 20 selected small cardamom accessions. As was reported earlier most of the SSRs profiles are monomorphic in cardamom but 2 uniquely polymorphic SSRs were identified predominantly separating the different cultivars and cardamom genotypes based on their place of collection. This indicated that the cardamom genome, as it is a monotypic genus, is highly conserved with little detectable molecular variations at microsatellite regions. The present study reports 11 monomorphic and 2 polymorphic microsatellites for genome analysis in cardamom.

P-04

Morphological characterization of lemongrass genotypes

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Lemongrass is a tropical perennial plant which yields aromatic oil. The characteristic smell of oil makes its use in scenting of soaps, detergents, insect repellents. Many morphological characters like pigmentation, development pattern, colour of leaf sheath, development pattern, hairyness of leaf, orientation of leaf *etc.* are being used in identification of crop varieties as they are found useful and act as descriptors of crop varieties. Characterization using these plant morphological characters in lemongrass showed that there is wide variability among the genotypes tested and these characters can be used for varietal identification. In the present study, seven qualitative characters were used to characterize the seven genotypes of lemongrass. Based on colour of leaf, genotypes were grouped into two, pale green and green. And based on colour of leaf sheath, genotypes were grouped as red, light red, greenish red and ashy green. The tillers have divergent growth for only one type whereas six types have compact growth. Among the tested genotypes all possessed hairs on leaf blade. The results of characterization showed that there is wide variability for all the characters like colour of leaf, colour of leaf sheath, development pattern, leaf orientation *etc*. The results suggested that the plant morphological characters could be used for broader classification of the genotypes.

P-05

Quality assessment of lemongrass oil in different genotypes

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In the present investigation, an attempt has been made to identify lemongrass (*Cymbopogon flexuosus* Nees) genotypes with high citral content along with higher oil yield. The experiment consisted of seven genotypes developed by public institutions. Citral analysis of oil was performed by gas chromatograph. The peaks of major constituents namely citral a and citral b, were identified and added to get total citral content. For citral content, all the genotypes were identified as stable across the environments which had non-significant regression co-efficient and deviation from regression. Genotype Cauvery recorded higher mean value for citral content followed by OD-19 and CKP-25. Oil yield of genotype Krishna was higher among all the genotypes. From the above results, it could be concluded that no single genotype is stable for oil yield and all the quality traits.

P-06

Genetic diversity analysis in *Piper* species (Piperaceae) using SSR markers

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In the present study genetic diversity of 24 known species of *Piper* was analyzed using 27 SSR primers. Most of these primers gave good polymorphism among the species studied and gave good SSR profiles. The molecular data of was scored and genetic similarities were calculated using the Jaccard similarity coefficient, the resulting similarity matrix. This was subjected to the UPGMA algorithm clustering method for Phylogram construction and Species inter-relationships. The dendrogram generated with SSR data divided the *Piper* species into 4 major clusters 2 of which were further divided in to sub clusters. In general the clustering was in tune with the accepted understanding of *Piper* species. The clustering also separated the Indian species from the exotic species and to an extent the north eastern species also. But this did not agree with earlier classification of grouping the *Piper* species based on spike orientation in that all erect spiked species were placed in large group Pipali. The SSR profiles in the present study displayed good polymorphism and inter relationships in *Piper* which confirms the suitability of SSR markers for discrimination of the *Piper* species.

P-07

Evaluation of fenugreek genotypes in northern transitional tract of Karnataka

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Studies were undertaken in fenugreek (*Trigonella foenum-graecum* L.) with nine genotypes having diversified origin to assess the *per se* performance of genotypes under Northern transitional tract of Karnataka during *Rabi* of 2010. The genotypes studied were DFC-1, DFC-2, DFC-3, DFC-4, DFC-5, DFC-6, DFC-7, Gujarat Methi-2 and Panta Ragini. Plant height varied significantly among the genotypes with DFC-2 (86.71 cm) recording the highest plant height followed by DFC-3 (79.94 cm) while, DFC-7

recorded minimum height (58.63 cm). The number of days from sowing to 50% flowering DFC-5 (32.63 days) took minimum days followed by DFC-6 (33.00 days) and DFC-3 (33.42 days) which were on par with DFC-5. Panta Ragini (35.33 days) took maximum days for 50% flowering. Number of pods per plant at different stages varied significantly among the genotypes DFC-5 (54.80) recorded the highest number of pods. Panta Ragini recorded minimum number of pods per plant. Significant difference in pod length was observed among the genotypes; GM-2 (20.13 cm) recorded the highest pod length followed by DFC-1 (19.83 cm) and DFC-2 (19.83 cm). Only Panta Ragini (17.00 cm) recorded significantly lower pod length, remaining genotypes were on par with GM-2. Number of seeds per pod varied significantly, DFC-2 (18.43) recorded the highest number of seeds per pod followed by DFC-1 (18.37). DFC-2 (1.83 g) recorded the highest seed weight followed by DFC-3 (1.65 g) which was significantly lower than DFC-2. Based on *per se* performance the genotypes DFC-2 (20.13 q/ha), DFC-1 (19.72 q/ha) and DFC-7 (19.63 q/ha) were found superior for yield while the lowest yield was recorded by the Panta Ragini (12.58 q/ha).

P-08

Germplasm evaluation in cardamom

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Survey was undertaken to collect superior genotypes with special characters *viz.*, high yield, tolerance to biotic and abiotic stress conditions and good quality capsules (possessing boldness, parrot green colour, superior aroma as well as flavour). A total of 159 cardamom accessions are presently conserved in the gene bank. The yield performance was good and the highest fresh yield of capsules (6300 g $plant^{-1}$) and dry yield (1400 g $plant^{-1}$) of capsules was recorded in CRSP 84 followed by CRSP 26 with 4400 g $plant^{-1}$ and 978 g $plant^{-1}$ of fresh and dry yield, respectively. CRSP 61 recorded maximum 100 capsule volume (180 cc) and weight (115 g) followed by CRSP 30 (175 cc and 100 g) suggesting higher boldness and lighter weight of capsules. These two attributes determines the market price of cardamom. Dryage percentage of CRSP 158 was found to be highest (23.2%) confirming its superiority in recovery percentage than all other accessions under study. CRSP 158 was also found to be tolerant to thrips. Thrips infestation was highest in CRSP 48 (52%) followed by CRSP 47 (45%). CRSP 44 was found to be susceptible to *azhukal* disease (40%). The capsule borer damage was recorded lowest for all accessions.

P-09

Bivariate and correlation studies in ajowan genotypes

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Correlation studies were carried out for seed yield with some of its component traits in 25 genotypes of ajowan (*Trachyspermum ammi* L.). The genotypes were collected from ajowan growing areas of Virudhunagar district of Tamil Nadu during 2010. Six morphological and reproductive traits *viz.*, plant height, days to 50% flowering, number of primary branches per plant, number of umbels per plant, number of umbellets per umbel and seed yield per plant were recorded. The recorded data were subjected to statistical procedures to study the bivariate and correlation analysis between seed yield with morphological and reproductive traits. In bivariate analysis, the genotypes ACC 16, ACC 19 and ACC 25 recorded the highest performance and ACC 2 had lowest performance among the genotypes studied. The results revealed the existence of the positive association between seed yield and its components in ajowan. Therefore, it would be highly rewarding to lay due emphasis on the selection of these traits for rapid high seed yield in ajowan.

P-10

Performance of local garlic genotypes under northern transition zone

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The local varieties of garlic were evaluated for growth and yield parameters under network project on onion and garlic. Among local varieties evaluated DWDG-1 recorded highest plant height (50.53 cm), number of leaves (13.10) and leaf length (31.17 cm) followed by RAS-1. With respect to yield parameters also DWDG-1 showed the highest average bulb weight (10.52 gm per plant) with marketable yield of 42.17 q/ha. DWDG-1 was found to be best among local varieties with respect to growth and yield parameters.

P-11

Early maturing garlic variety: DWDG-1

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DWDG-1 is a selection from a local material. This variety matures in 85 days compared to other local and commercial varieties, which mature commonly in 125 days. This variety was characterized for morphological, growth, quality and yield characters. The variety produces light green pseudo stem, coloured heart shaped mature bulb and white coloured cloves are present externally. It has plant height of 50.53 cm, 13 leaves on an average, 30,17 cm leaf length and 1.52 cm leaf width and has good marketable yield (42.17 q/ha) in a very short period of 85 days. This variety can tolerate biotic stresses (purple blotch, thrips) and farmers can earn very good income.

P-12

Taxonomic description of indigenous garlic genotypes of north Karnataka

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Fourteen local varieties were evaluated for their morphological and quality parameters in MARS, Dharwad under Network project on onion and garlic. Among local varieties evaluated DWDG-1 recorded pseudo stem length, polar diameter and equatorial diameter of 10.13 cm, 25.25 mm and 29.52 mm respectively. Next to DWDG-1 DWDG-5 has 21.25 cm of pseudo stem length, 22.80 mm of polar diameter and 37.36 of mm equatorial diameter. With respect to morphological characters DWDG-1 produces light green pseudo stem coloured heart shaped mature bulb and cloves are present externally, which are having white coloured clove and bulb too. Hence DWDG-1 has been found to be best among local varieties with respect to quality parameters.

P-13

Evaluation of ginger genotypes for growth, yield and quality under coconut ecosystem

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Investigation on evaluation of ginger (*Zingiber officinale* Rosc.) genotypes for growth, yield and quality under coconut ecosystem was conducted in a farmer field at Sethumadai near Pollachi in Tamil Nadu during 2010-2011. The experiment was laid out in Randomized Block Design with three replications using eight ginger genotypes *viz*., Varada, Nadan, Kerala, Malaiinji, Maran, Idukki 1, Idukki 2, and Idukki 3. Among the eight genotypes, Idukki 2 recorded higher growth parameters and the physiological parameters such as higher leaf area and leaf area index. The yield parameters *viz*., mother, primary, secondary and tertiary rhizomes, per plant yield, per plot yield and estimated yield per hectare were found maximum in Idukki 2 respectively. With respect to quality the genotypes *viz*., Nadan recorded higher oleoresin, Malaiinji recorded higher crude fibre and Idukki 1 recorded higher essential oil content respectively under coconut shade. The benefit cost ratio was found higher in Idukki 2 than other genotypes evaluated under coconut ecosystem. Considering the overall performance in terms of growth, physiological, yield parameters and economics of cultivation it could be concluded that the genotype, Idukki 2 recorded better performance under coconut shade.

P-14

Genetic variability in chilli genotypes under natural condition

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The extent of genetic variability, heritability and genetic advance as per cent of mean in respect of 27 quantitative characters in 80 chilli genotypes was studied under natural condition. There was a high phenotypic and genotypic coefficient of variations for yield characters like fruit yield, late fruit yield and total fruit yield and for quality parameters like fruit length, breadth, density, chlorophyll ‘a’ and ‘b’, ascorbic acid and capsaicin and for red chilli parameters like fresh red chilli yield, dry red chilli yield and number of seeds per fruit. High heritability and genetic advance as percent of mean was observed for the characters plant height and plant spread (East-West and North-South). Among the yield characters, days to first flowering, number of fruits per plant, late fruit yield and total fruit yield; among green fruit characters fruit breadth, ten fruit weight, fruit density, chlorophyll ‘a’ and ascorbic acid and among red chilli parameters like fresh red chilli yield, dry red chilli yield, number of seeds per fruit, seed weight per fruits showed high heritability and genetic advance as percent of mean. The traits such as growth parameters, green chilli fruit characters, quality parameters and red chilli fruit characters are important yield contributing characters and deserve due weightage, while formulating selection strategies for improvement of chilli under natural conditions.

P-15

Correlation and path analysis studies in chilli

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Correlation and path analysis in eighty genotypically diverse indigenous and exotic genotypes of chilli (*Capsicum annuum* L.) were studied for 13 important characters. The genotypic correlation was more than the phenotypic correlation for all the traits. The phenotypic and genotypic association of fruit yield was significantly positive with all the characters except days to first flowering and fruit weight. Early and late fruit yield per plant showed significant positive correlation with total fruit yield which could be due to more number of fruits produced by the early and late genotypes. The genotypic and phenotypic path coefficient analysis revealed that total green chilli had high direct positive effect from early and late fruit yield. So selection should be done based on early and late fruit yield for better rewards.

P-16

Variability for sex expression and related traits in hybrids of betel vine

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Crop improvement in betel vine (*Piper betle* L.) through hybridization is being carried out at Indian Institute of Horticultural Research involving female and male clones. The ongoing work has generated many segregating hybrid population. The sex expression and leaf traits have been studied in field planted flowering hybrids. Flowering is recorded in twenty two hybrids after two and half to three years of field planting. Among 22 hybrids 1:1 ratio for sex segregation was observed. 90% of the female hybrids exhibited greater plant vigor and good leaf size. Significant variation was recorded for leaf shape from ovate, ovate to lanceolate (narrowly ovate) and lanceolate. The leaf length: breadth ratio varied from 1.26 to 2.16. More than 80% of the male hybrids exhibited poor vigor, leaf size. Greater variation was observed for leaf size and shape among the male hybrids. Hybrid 06-4 though male put forth typical ovate leaves which are generally observed in female germplasm. The leaf length: breadth ratio varied from 1.27 to 2.58. Significant variation for length (1.50 to 8.7 cm) and girth (1.00 to 1.91 cm) of male catkin was also recorded. The leaf traits in hybrids varied significantly from the generally observed linkage between sex and leaf shape (narrowly ovate in males and ovate in females) and length: breadth ratio (1.84 ±0.21 in male and 1.26±0.13 in female) in the germplasm. This could be due to the recombination occurring through sexual reproduction. The variations in the male hybrids may be due to abnormalities in the segregation of factors responsible of male sex expression.

P-17

Organogenesis in cumin

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Aseptically grown seedlings (15-17 days old) of cumin (*Cuminum cyminum* L.) variety RZ-19 were used to obtain explants like shoot apex, hypocotyls and leaves. These explants were inoculated on MS medium supplemented with various levels of cytokinins and auxins added singly or in combinations. Shoot apex explants when incubated in the medium supplemented with 1.0 mg l^{-1} NAA induced roots and flowering (50 days after inoculation). Seed formation was also recorded after 65-70 days of inoculation. Callus and multiple shoot induction in shoot apex explants were observed at 0.3 mg l^{-1} BAP and 0.3 mg l^{-1} kinetin, respectively. 0.1 mg l^{-1} NAA induced roots from leaf explants. Profuse callus differentiation was observed at 0.3 mg l^{-1} BAP with 100 per cent response in shoot apex explants. This callus was assessed for its organogenetic capacity. Three subcultures on 0.3 mg l^{-1} BAP induced *in vitro* shoot regeneration. When these regenerated shoots were sub-cultured on MS medium supplemented with 1.0-3.0 mg l^{-1} NAA induced roots at the base and complete plant was obtained. The genotypic differences for response to callusing and regeneration were also observed. The genotype RZ-19 recorded high response with shoot apex at 0.3 mg l^{-1} BAP while the response using hypocotyl was best with genotype UC-231.

P-18

Stability analysis in fenugreek

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Forty two genotypes of fenugreek (*Trigonella foenum-graecum* L.) were evaluated over four environments during *rabi* 2010-11 to estimate stability parameters for days to 50 per cent flowering, plant height, branches per plant, pods per plant, pod length, seeds per pod, test weight and seed yield. Environment wise analysis of variance was significant for all the traits in all the environments. Genotype x environment interaction was significant for all the characters except branches per plant and pod length. Environment + (variety x environment) component was significant for most of the traits *viz*., days to 50 per cent flowering, plant height, pod length and seed yield. The pooled analysis was significant for all the traits except branches per plant. The environmental indices of each character had wide differences for seed yield ranging from -6.947 in environment-iv to 8.763 in environment-I as well as for other characters. The genotypes chosen varied widely in their mean seed yield, ranging from 15.59 gm (UM-11) to 32.35 g (UM-24). The highest yielding genotype was UM-24 followed by UM-27, RMt-1 and UM-29 among 42 genotypes of the present study. Mean seed yield was linearly influenced by the environment. The test weight and branches per plant were least affected by environments. Genotypes UM-36, RMt-303, UM-4 and UM-30 were relatively stable for seed yield. They may be used in hybridization programme to generate stable genotypes. Genotypes UM-24, UM-19, UM-27, UM-29, UM-26, RMt-351, UM-7, UM-18 and Local have below average stability for the seed yield and suitable for better environment. Genotypes UM-6, UM-34 and UM-2 have above average stability for seed yield and suitable for poor environment.

P-19

Effect of surface sterilants on contamination and percent survival of tamarind explants

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A study on micropropagation of tamarind (*Tamarindus indica* L.) was conducted. Surface sterilization was done with two chemicals or mature shoot explants of tamarind viz., $HgCl_2$ at 0.05, 0.1 and 0.2 % and NaOCl at 0.5, 1.0 and 2.0 % for 2, 4, 6, 8, and 10 minutes duration. Subsequently, the effect of the treatments on per cent survival of explants was observed. The data revealed that $HgCl_2$ at 0.1 % for 10 minutes duration was the best with respect to percent contamination (0) and survival percent (100%). Higher concentrations or duration though had least contamination, the explants failed to survive in these treatments.

P-20

Yield and ancillary data in coordinated varietal trial of turmeric

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Eight genotypes of turmeric including two checks (Prabha and NDH-1) and those received from different centres of All India Coordinated Research Project on Spice crops were evaluated. Maximum yield of 309.99 q/ha was obtained in RH-80 followed by TCP-70 (304.44 q/ha). RH-9/90 had maximum plant height of 97.45 cm and lowest plant height (90.56 cm) was recorded in TCP-70. Genotype RH-80 had maximum number of leaves/shoot (6.78) and tillers per plant (2.67). Weight of fresh rhizomes per plant (227.23), yield per plot (9.30) and maximum length of leaves (47.12 cm) in were observed in TCP-139 and maximum number of primaries (3.56) in TCP-70. There was not much difference in secondaries turmeric among the genotypes and number of secondaries ranged from 5.12 to 6.56.

P-21

Hisar Mukta: a high yielding variety of fenugreek

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Hisar Mukta (HM-346), a high yielding variety of fenugreek has been developed through mutation breeding at the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar. In view of its superior performance compared with national level variety Pusa Early Bunching at Hisar and standard checks at other co- ordinating centers and being resistant to downy mildew disease, the variety has been recommended for National release during XVI Workshop/ Group meeting of All India Co-ordinated Research Project on Spices held at Kerala Agricultural University, Vellanikkkara, Thrissur (Kerala) and later on notified for National release by 12th Meeting of Central Sub-Committee on Crop Standard, Notification and Release of Variety for Horticultural Crops held on 5th October, 2005. This is a high yielding variety producing 2000-2300 kg/ha of seed yield and resistant to downy mildew disease.

This variety is suitable for cultivation in the states of Haryana, Rajasthan and Gujarat during winter season both under irrigated and rain-fed conditions.

P-22

Performance of garlic genotypes to purple blotch caused by *Alternaria porri*

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In the present investigation 18 genotypes and 14 local cultivars of garlic were screened at MARS, Dharwad, for evaluating their resistance levels against *Alternaria porri* under natural field condition during Rabi 2009. The reaction of disease was graded on 0 to 5 scale. Results indicated that one genotype *viz*., BGSDRB0909 performed best among all the tested cultivars by displaying highly resistant reaction and five genotypes showed moderately resistant reaction to purple botch disease while three genotypes displayed highly susceptibility reaction. Among the local genotypes, HRG displayed highly resistant reaction. Moderate resistance was observed in seven genotypes while RK-1 displayed highly susceptible reaction to *Alternaria porri.*

P-23

In vitro induction of rhizomes in turmeric

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Influence of growth regulators, medium strength and photoperiod on microrhizome induction in turmeric (*Curcuma longa* L) was studied. Best response was obtained in medium containing BAP 1mg l^{-1} with NAA 0.2 mg l^{-1} (31.33 days) followed by BAP 1 mg l^{-1} alone (43.33 days) for early induction of microrhizomes. More number of microrhizomes and bigger microrhizomes were produced in lower concentration of BAP. Full strength MS medium recorded higher number of microrhizomes, weight of microrhizomes and nodes per microrhizome which was followed by half strength medium. Further, interaction between photoperiod condition and media types showed that dark condition with liquid and semisolid medium produced the highest number of microrhizomes per shoot (7.00).

P-24

Collection, conservation and exploitation of natural genetic diversity of coriander for breaking yield plateau

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The genus Coriandrum includes the cultivated plant *Coriandrum sativum* L. and the wild species *C. tordylium*, an annual species very similar to the cultivated *C. sativum*. The wild species might be interesting for coriander breeding, but it has not been reported whether crossing *C. sativum* and *C. tordylium* may be possible. Bifora, a specific weed of coriander is the closest genus to Coriandrum.

Efforts have been made to use *B. radians* as a genetic resource in coriander breeding but successful crosses could not be obtained even using embryo rescue techniques, possibly due to the difference in their chromosome number. Besides the above two, the possibility of exploitation of wild coriander (*Eryngium foetidum*) belonging to the same family, having a similar aroma as fresh coriander leaves is also yet to be seen. Future research can be concentrated on the identification and exploitation of this untapped genetic diversity for breeding and crop improvement.

P-25

Germplasm collection and evaluation of cinnamon accessions

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Cinnamon being an important commercial crop of high rainfall zone of Kanyakumari District. A trial on germplasm collection and evaluation of cinnamon accessions was undertaken. Nine elite cinnamon selections collected from local estates such as Maramalai, Zero point and Nagercoil locations of Kanyakumari District are under evaluation. Among the accessions sel.7 performed well and gave the bark yield of 420 g. of dried bark/tree and leaf yield of 6.3 kg/tree. A local collection from Pechiparai has recorded the leaf yield of 6.0 kg/tree and bark yield of 314.75 kg/tree.

P-26

Evaluation of garcinia germplasm for yield and quality

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The objective of the study was to collect and evaluate Garcinia types for yield and quality. Eleven accessions collected from different places *viz.,* Devicode, Cheruvarakonam, Kollencode and Zeropoint and planted during 1992 at Horticultural Research Station, Pechiparai are being evaluated. The performance was studied and compared with Pechiparai local as check. It was observed that among the accessions GC-9 recorded the highest yield of 72.5 kg/tree. Fruit rind of this selection is rich source of HCA (28.6%) which is an important raw material in the manufacture of medicine/health tonic controlling obesity.

P-27

GC-9 a promising culture for the humid tropics

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Kudampuli PPI (K) 1 is a clonal selection from the germplasm maintained at Horticultural Research Station, Pechiparai. The tree is much adapted to humid tropical areas receiving annual rainfall of more than 1500 mm and elevation ranging from 100-500 m above MSL. It is a perennial tree and grows up to a height of 10 m. the fruits are highly acidic and used as an alternative for tamarind in culinary preparations. The grafts come to bearing from the third year onwards. More number of fruits per plant (257.31). It gives a mean yield of 64.04 kg/tree and 40 tonnes/ha. The dry recovery per cent is high (15%). It is a high yielding type recording 24.0 per cent higher fruit yield than Pechiparai local. The extract obtained from the matured fruit rind is the rich source of (28.6%) hydroxy citric acid (HCA).

P-28

In vitro clonal propagation and induced mutagenesis in turmeric

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Studies were conducted to standardize the protocol for *in vitro* clonal propagation of turmeric (*Curcuma longa* L) and the optimum dose of chemical mutagens for *in vitro* raised plants, to study the variability in the induced mutants. *In vitro* studies for clonal propagation of turmeric indicated that the highest number of multiple shoots in turmeric was obtained in MS medium supplemented with 2.0 mg l^{-1} BAP and 0.2 mg l^{-1} NAA whereas, better rooting was obtained with 0.5 mg l^{-1} IBA. The *in vitro* mutation studies in cv. Salem with chemical mutagens indicated that the LD_{50} for EMS was 114.58 µM and DES was 28.80 µM. Both mutagens increased the variability in vegetative and reproductive characters. Mutants D-1-3 (318.25g) and E-200-4 (285.83g) recorded the highest rhizome yield whereas D-10-3 recorded the highest curcumin content.

P-29

Sensitivity of two turmeric varieties to gamma irradiation

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Being a vegetatively propagated crop, mutation breeding is an important tool in turmeric (*Curcuma longa* L.) improvement. Studies were conducted to standardize the optimum dose of mutagen i.e., gamma irradiation in two turmeric varieties. Among the two cultivars evaluated, Salem was more sensitive to gamma irradiation with a LD_{50} dose of 1.135 kR compared to Cuddappah (2.69 kR). Mutant spectrum showed predominance of striata type and dwarf types in chlorophyll and morphological mutants respectively.

P-30

Diversity in small cardamom collections based on inter-simple sequence repeats

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The present study reports molecular characterization of 95 important genotypes representing genetic diversity of small cardamom (*Elettaria cardamomum* Maton) using 20 ISSR markers. Fifty inter-simple sequence repeat (ISSR) universal primers from UBC were screened and twenty best primer combinations were short listed and optimized. The molecular data of 66 loci were scored and genetic similarities were calculated using the Jaccard's similarity coefficient, the resulting similarity matrix was subjected to the UPGMA algorithm clustering method for dendrogram construction and cultivar differentiation. In total, 66 bands were amplified by 20 ISSR primers, resulting 25 (37.87 %) bands showed polymorphism at molecular level. The molecular data, as reported earlier, indicated low molecular variation among cardamom genotypes and this need to be further supplemented with more data before Core collections are short listed. The study also indicated that short listing of cardamom core collection based on molecular data alone is not advisable and needs to be supplemented with morphological and other biochemical data.

P-31

Genetic analysis and purity test in certain varieties and hybrids of chilli and paprika

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An investigation was undertaken for the analysis of genetic diversity of capsicum germplasm using RAPD and SSR markers. Thirteen genotypes of capsicum both from chilli and paprika type were used to analyze the genetic variation with twelve RAPD and nine SSR primers. The RAPD primers produce 78 bands of which 65 were polymorphic. The number of bands per primer varied from 4 to 10 with a mean of 6.5. The similarity value from RAPD matrix ranged from 0.36-0.91 with mean of 0.62. The average number of alleles per polymorphic SSR locus was 3.22, ranging from one to six. Polymorphic information content (PIC) values of the SSR loci tested ranged from 0.00 to 0.75 with average value of 0.546 while the pair wise similarity coefficient analysis from SSR markers produced mean value of 0.39. This indicates that microsatellite markers have a different polymorphic capability than RAPD markers. The resulting RAPD dendrogram separated the cultivars with erect fruit position from the large fruited cultivars with declining fruit position. The small and erected fruit cultivar from *Capsicum frutescens* showed high divergence. The clustering obtained from SSR marker showed some similarity with RAPD clustering and some difference in positioning of few genotypes is observed. In another experiment on analysis of cultivar identification and hybrid purity test, two DNA molecular marker systems, RAPD and SSR, were used to test genetic purity of three chilli hybrid cultivars CCH1, CCH2, and CCH3 genomic DNA from the two F1 hybrid cultivars and their corresponding parental lines were screened with 20 RAPD decamer primers and 9 SSR primers. Among the 20 RAPD primers used two primers for CCH2, and CCH3 and one SSR primer for CCH1 which could produce male parent-specific markers, were identified and could be used for testing the genetic purity. Moreover, five RAPD markers produced different markers that could be used for identification of eight cultivars from the thirteen genotypes used in the study.

P-32

Computational prediction of novel candidate microRNAs from turmeric

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MicroRNAs (miRNAs) are a class of endogenous non-coding, short (19-24) RNAs directly involved in regulating gene expression at the post transcriptional level. In the present study, an EST based approach has been used to identify novel miRNAs from turmeric (*Curcuma longa* L). Identification of miRNAs was initiated by mining the EST database available at NCBI. Total of 12,593 ESTs were obtained for miRNA identification and mature sequences of known miRNAs from from nine plants from miRBase were subjected to a BLASTn search against *C. longa* EST sequences. Eight candidate miRNAs were identified in turmeric by a sequence similarity search followed by a set of structural filters for predicting RNA secondary structure using mFold software. Among these four novel miRNAs were identified *viz*., a) UGAAGCUGCCAGCAUGAUCUGG b) 5'GGCGAGCUUCUCGAAGAUGUCGU3' c) 5'AGGAUGUCUUUGCUGGUGGC3' and d) 5'UCAAAGAAGUCGCUGAGGU3'.

P-33

DNA profiling and identification of black pepper varieties using ISSR, SSR markers and morphological characters

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In the present study Inter-Simple Sequence Repeat (ISSR) profiling of 16 released varieties of black pepper (*Piper nigrum* L.) was done using 39 ISSR primers and 9 Simple Sequence Repeats (SSR) primers. Out of 39 ISSR primers used, 16 ISSR primers and 4 SSR primers gave the best result with reproducible polymorphic bands among the varieties. Genetic similarity was calculated using the Jaccard's similarity coefficient and dendrogram of similarity was drawn. The dendrogram has separated most of the varieties. Clear differences were noticed among the varieties in ISSR and SSR profiles. Unique bands were identified for most of the varieties. A key was developed for identification of black pepper varieties using morphological and molecular data. This will help in testing genetic purity / fidelity of these varieties for certification in multiplication of large scale planting material programmes.

P-34

Development of DNA diagnostic markers in released varieties of turmeric

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The potential of Inter simple sequence repeats (ISSR) markers for molecular profiling was assessed in turmeric (*Curcuma longa* L.) using a panel of 7 released varieties of IISR, Calicut. The varieties were screened with 76 ISSR primers, of which 36 were selected. Unique DNA diagnostic bands were observed for IISR Suvarna, IISR Suguna and IISR Sudharsana. The developed varietal-diagnostic markers can be used for the precise and rapid identification of varieties during large scale planting of Turmeric. Adulteration could be detected to a greater extend with this methodology.

P-35

Characterization of Malabar tamarind accessions

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Twenty six Malabar tamarind Malabar tamarind [*Garcinia gummigutta* (Gaertn.) Desr.] genotypes maintained at IISR, Appangala were characterized for their fruit and yield performance under high altitude and high rainfall Kodagu region of Karnataka (India). Among the genotypes studied, IC 549117 was found to be the best, recording maximum fresh fruit weight and number of fruits per tree. The accession, IC 549128 recorded the maximum pulp/seed ratio. It was also noticed that the seeds yielded high amount of butter (50%) which was creamy yellow in colour with pleasant aroma.

P-36

Genetic diversity in kokum (*Garcinia indica*) in Western Ghats of South India

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Surveys were conducted during 2007 to assemble and evaluate the kokum (*Gancinia indica* choisy) genetic diversity in Western Ghats region of Karnataka, Goa and Maharashtra states. A total of 12 selections were evaluated for fruit characters during 2007. Among the selections, S-39 (22.14 g) recorded significantly highest rind weight. Kokum selections S-41 (13.02 g) and S-42 (13.43 g) are also good source of kokum rind.

P-37

Screening of onion advance lines for better storability

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For screening of better storage onion genotypes, harvested bulbs of 11 red advanced onion lines and check variety Arka Kalyan were kept in plastic crates to study the post harvest performance of these lines at division of Vegetable Crops, IIHR, Bangalore. The results revealed that three lines PBR-138, PBR-139 and PBR-140 showed less than 10% rotten and sprouted bulbs. The rest of the lines AN 413, AN 414, AB 128, PBR 143, AK 160, AN 184, AN 187, AP 195 and commercial check Arka Kalyan recorded more than 10% losses due to sprouting and rotting.

P-38

Evaluation of red onion elite lines for bulb yield and yield attributes

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The present investigation was undertaken with eleven elite advanced lines along with Arka Kalyan as check variety to study the bulb yield and yield attributing parameters. The results revealed that genotype AK 160 showed highest total bulb yield (21.25 t/ha) and marketable bulb yield (18.25 t/ha). The yield attributing characters like ten bulb weight (400 g.), number of leaves (6.85) and bulb diameters (polar and equatorial) were also found high in the genotype AK160. Minimum total bulb yield in the experiment was recorded in the genotype AB 128 (15 t/ha).

P-39

Induction and field performance of *in vitro* microrhizomes of turmeric for production of disease free planting material

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This study aimed at developing a technique to produce disease free planting material through *in vitro* propagation. The effect of various concentrations of MS salt (0.25, 0.5,0.75 and 1x), sucrose (5,7,9,11%), culture duration (30,60,90,120 days) and different growth hormone (benzyladenine and kinetin alone at 0.5,1.0,1.5mg/l and benzyladenine (0.5,1.0,1.5) and α- naphthalene acetic acid (0.5) in combination, on *in vitro* rhizome formation of turmeric (*Curcuma longa* L.) variety 'Prabha' were studied. *In vitro* rhizome formation occurred in all the above treatments. Addition of 1 mg/l benzyladenine (BA), 0.5 mg/l α- naphthaleneacetic acid (NAA), 90 g/l sucrose, 0.8% agar and 0.75 x Murashige and Skoog's (1962) medium showed more significant effect on microrhizome formation. The microrhizome derived plants on field evaluation showed a significant increase in number of tillers, no of leaves but showed reduction in fresh rhizome size and weight weight per plant when compared with conventionally propagated plants. The genetic fidelity among microrhizome derived plants assessed by random amplified polymorphic DNA (RAPD). Volatile oil components of microrhizome were identified using GCMS.

P-40

Genetic divergence in betelvine

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An attempt was made in the year 2009 to study the genetic divergence in 51 genotypes of betelvine (*Piper betle* L.) for seven characters using Mahalanobis D^2 technique. The genotypes were grouped into six clusters. The clustering pattern of the genotype was random and did not follow

geographical origin, indicating that geographical isolation may not be the only factor causing genetic diversity. Leaf area contributed maximum genetic diversity in betelvine. Cluster analysis revealed wide genetic distance between cluster V and cluster VI followed by cluster IV and cluster VI and cluster III and cluster V. Thus, selection of parents may be performed from the clusters with high inter and intra cluster distances routes to obtain substantial heterosis in respect of economic traits during hybridization programme.

P-41

Hisar Bhoomit: a leafy type variety of coriander

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The objective was to develop higher green leaf yielding variety of coriander, which resulted in the development of Hisar Bhoomit (DH-228), a high leaf yielding variety. This variety is higher green leaf yielder with high oil content and resistant to stem gall disease, suitable for cultivation through out the country. Its round shaped seeds are smaller in size with high volatile oil content i.e. 0.66%, which is much higher than average value for coriander and other released varieties (0.30%). This variety out yielded other varieties and National check Pant Haritima under CVT at Hisar and Coimbatore centers over three years and suitable for cultivation throughout the year for leaf purposes. It was recommended for state release during XVIII Workshop/ Group meeting of All India Co-ordinated Research Project on Spices held at Bhubaneswar (Orissa) and recommended for inclusion in package of practices by the Horticulture Officers Workshop held on Jan.16-17, 2008 at CCS HAU, Hisar.

P-42

Cytoplasmic male sterility based chilli hybrids for tolerance to high temperature and resistance to seedling blight

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Colletotrichum capsici and *C. gloeosporioides* are the known causal agents of anthracnose in chilli of which *Colletotrichum capsici* is more important. One hundred fifty F_1 hybrids were obtained from 3 females (with cytoplasmic male sterility) (tester) and 50 males (lines) and these were evaluated to study the fruiting ability in shade house during March to July in 2009-2010 and 2010-2011. These were screened for seedling blight resistance in both shade houses and in the field in the *Kharif* (rainy season) of 2009-2010. Only 30 hybrids set fruits in the summer season. Hundred per cent fruit setting (fruit set in all the plants) was recorded by hybrid ACBGA1/HO413, ACBGA1/D.DABBI and JNKVVA1/LCA310A. Fifty per cent fruit setting was recorded in ACBGA1/KDC1. Interestingly three hybrids *viz*., ACBGA1/HO413, ACBGA2/H0413 and JNKVVA1/H0413 set fruits which have common male parent (H0413) and three different female parents. Screening for seedling blight resistance was done under natural epiphytotic condition during August to September months of *kharif* season of the year 2009. Genotypes, LCA310A, LCA960 and GCV121 showed resistance against seedling blight.

P-43

Stability, correlation and path analysis for fruit yield and its component in chilli

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The present investigation was carried out to identify stable and high yielding genotypes of chilli (*Capsicum annuum* L.) for cultivation in Kymore Plateau and Satpura Hill region of Madhya Pradesh through stability analysis and to understand the type of association among characters and the extent and nature of direct and indirect effect of component traits on dry fruit yield. Twenty cytoplasmic genetic male sterility based F_1 hybrids and three promising genotypes along with one check were evaluated in three different environments for stability analysis during *kharif* season of 2009-2010. The correlation and path coefficient analysis were studied in 75 genotypes for 18 different quantitative characters. Variance due to genotypes x environment interaction was significant for all the characters except number of fruits plant^{-1} and fresh fruit weight plant^{-1}. Considering all the stability parameters, JCH47, BCH24 and BVC37 exhibited wider stability for dry fruit yield plant^{-1}, JCH01 had stability for favourable environment and JCH05, JCH14, JCH23, JCH24, JCH54 and RCH23 showed below average stability. Highest performing F_1 hybrid JCH54 was identified as stable performer under unfavourable environment for dry fruit yield. The highest correlations were found with dry fruit weight plant^{-1} and fresh fruit weight plant^{-1} (r = 1.00), number of fruits plant^{-1} (r = 0.63), dry fruit weight fruit^{-1} (r = 0.44), number of seeds fruit^{-1} (r = 0.35), fresh fruit weight fruit^{-1} (r = 0.32) and fruit length (r = 0.28). Path analysis indicated that the number of fruits plant^{-1} and fresh fruit weight fruit^{-1} were the two factors that exerted the greatest influence both directly and indirectly upon the dry fruit yield.

P-44

Performance of allspice genotypes in high rainfall zone

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A survey was conducted at Maramalai, Cheruvarakonam, Karumparai, Pechiparai and Arukani regions of Kanyakumari and a total of 9 accessions of allspice [*Pimeta dioica* (L.) Merr.] were collected and maintained at Horticultural Research Station, Pechiparai to assess the growth and yield traits of the types under this region. Observations on growth characters were recorded and among the 9 accessions under evaluation P.D 1 performed well and recorded the highest plant height (620cm), plant girth (42.5 cm), number of primary branches (14.0) and secondary branches (48).

P-45

Chromatographic fingerprinting and estimation of organic acids in selected *Garcinia* species

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The aim of this study was to identify and estimate the total number of acids present in the dry fruit rinds of eight species of garcinia commonly available in Western Ghats and North Eastern Himalayas of India. Dry fruit rinds of eight species *viz*., *G. gummigutta, G. tinctoria, G. indica, G. mangostina, G. subelliptica, G. cowa* (Kuji thekara), *G. Pedunculata* (Bor thekara) and *G. lancifolia* (Rupohithekara) were used for the analysis of organic acids using paper chromatography**.** Total number of acids varied from 5 to 7. Total acids were highest in *G. cowa* (28%) and lowest in *G. mangostina* (4.49%). Estimation of organic acids using RP-HPLC showed that next to hydroxycitric acid, malic acid was present in high concentration. HCA was highest in *G. gummigutta* (10.48%) and lowest in *G. tinctoria* (0.05%). Malic acid content was highest in *G. cowa* (16.32%). It is interesting to note that all the North Eastern species have high malic acid content. This is the first report on the estimation of organic acids from the fruit rind of Indian Garcinia.

Quality planting material availability

P-46

Grafting in black pepper using wild species as rootstocks for resistance to quick wilt and slow wilt

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The two wild species of black pepper *viz., Piper attenuatum* Miq. and *Piper hymenophyllum* Buch.-Ham.ex Miq indigenous to lower pulney hills were explored for their resistance for devastating diseases, quick wilt caused by *Phytophthora capsici* and slow wilt caused by *Fusarium solani* and plant parasitic root knot nematode *Meloidogyne incognita*. Panniyur 1 and Karimunda were used as scion material for the rootstocks. Cleft grafting method was followed. Among the two wild species, *P. hymenophyllum* had more grafting success (42.78 per cent) than *P. attenuatum* (36.11 per cent) and among the scion material Karimunda had the higher grafting success (44.44 per cent) than Panniyur-1 (41.11 per cent) on *P. hymenophyllum.* On artificial inoculation of rootstock, scions individually and grafted plants with *Phytophthora capsici* in pot culture, the two rootstocks as well as their grafts recorded the reaction category of 'resistant' with lesion rating ranging from 0 to 1. For slow wilt, rootstocks and their grafts recorded 'resistant' reaction category (0% wilt) against *F. solani*. Further, when artificially inoculated with *Meloidogyne incognita* under pot culture, *P. attenuatum* and its graft combinations attained 'immune' category, while the *P. hymenophyllum* and its graft combinations attained 'moderately resistant' category (2.5 to 2.7 Gall index). Thus, *P. attenuatum, P. hymenophyllum* and their grafts exhibit multiple resistance to the devastating diseases, quick wilt and slow wilt.

P-47

Orthotropic shoot propagation in black pepper

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A propagation experiment on orthotropic shoot propagation in black pepper (*Piper nigrum* L.) was conducted during the year 2008-2009, 2009-10 and 2010-11 under AICRP on spices. Twelve treatment combinations of three types of cuttings (2, 3 and 5 nodes), three growth promoters IBA, PGPR (*Pseudomonas fluorescens*-108), 2% common sugar and a control (without any treatment) were evaluated in the experiment. Maximum rooting success (89.11%) was observed in three node cuttings which was at par with two node cuttings (86.88%). Among growth promoters, maximum rooting success (90.22%) was observed in PGPR treatment which was followed by common sugar (85.63%) treatment. The combined effect of types of cuttings and growth regulators indicate maximum rooting success in two node cuttings with PGPR treatment (97.32%) followed by three node cuttings with PGPR (96.44%) and two node cuttings with common sugar (90.21%) treatments. Economics of production of 1000 saleble black pepper cuttings showed highest net profit with two node cuttings with PGPR (Rs.3557/-) and common sugar 2% (Rs.3442/-) followed by 3 node cuttings with PGPR (Rs. 2853/-) and common sugar 2% (Rs. 2611/-) treatment. For obtaining higher success in black pepper propagation from orthotropic shoots, it is recommended to use two node cuttings (without leaves) treated with *Pseudomonas fluorescens*-108 powder formulation or dipped in common sugar 2% solution for one minute.

P-48

Effect of different grafting techniques in garcinia

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An attempt has been made to study the grafting techniques in *Garcinia gummigutta*. The results revealed that the maximum percentage of success of 74.45% and average number of sprouts (7.2) were observed in cleft grafting followed by whip type, which noted 66.45 percentage of success and 7 numbers of sprouts. So cleft grafting with average scion thickness of 4.40 mm and average stock thickness of 4.50 mm is ideal for mass multiplication of elite types of this tree species.

P-49

Propagation of *Artocarpus lakoocha* through grafting techniques

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A study was undertaken to standardize the grafting techniques in *Artocarpus lakoocha* Roxb. tree for mass multiplication of elite types. The results revealed that the cleft grafting technique was found superior which noticed maximum percentage of success (50.86), number of sprouts (3.0) and number of leaves per sprout (3.71) followed by whip type grafting technique, where percentage of success was 50.03%, average number of sprouts were 2 and average number of leaves per sprout were 3.45. So, cleft

grafting with average scion thickness of 5.0mm and average thickness of 4.9mm of stock is practically suitable for mass multiplication.

P-50

Farmer participatory seed production: key to address planting material shortage of HYV of spices

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The timely availability of seed and quality of seed are two important aspects for ensuring good crop by farmers. To address this issue, an attempt was made by KVK, Calicut in collaboration with National Horticultural Research and Development Foundation, Nasik to intervene in participatory seed production of HYVs of ginger (Varada) and turmeric (Prabha and Prathibha) developed by Indian Institute of Spices Research (IISR) by selecting progressive farmers and farmer groups and empowering them. Ten farmers and one farmer group were selected by giving weightage to their experience in seed production, possession of land, willingness to follow scientific methods etc. The selected farmers were given nuclear seed materials and plant protection chemicals and the farmers fields were inspected periodically and monitored by experts. In order to build up awareness on the production and importance of quality seeds at district level, a seminar was conducted and queries were solicited for seed requirement. The registered farmers were provided with seed later on during the "Seed Day" celebrations well in advance to ensure best performance in their field. The seeds were also sold through Kisan Melas organized at IISR, Calicut. A total of 4 tonnes of Prathibha, 5.6 tonnes of Prabha and 1.5 tonnes of Varada were produced as seed material by this intervention. The seed rhizomes were made available to 42 ginger farmers and 69 turmeric farmers in the district. The seed growers achieved a high B:C ratio of 3.8 compared to 1.6 for the conventional crop. Thus KVKs can play a vital role in making a district self sufficient in quality seeds of HYV of crops. Hence this programme is a viable option by empowering small farmers and farmer groups into market-oriented micro seed entrepreneurs.

Production system and plant health management

P-51

Comparative study of organic, integrated and traditional practices in garlic

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A field experiment was conducted to study the effect of organic, integrated and traditional practices in garlic (*Allium sativum*). The result revealed that, inorganic practices + panchagavya spray @ 3% at 30, 40 and 50 DAS recorded highest plant height and yield (56.67 cm and 9.86 tonnes ha^{-1} respectively), which was on par with INM practices - 50% organic (RDF) + 50% inorganic + biofertilizers *viz*., Azospirillum PSB and VAM.+ cow urine spray @ 10 % at 30, 40 and 50 DAS. Inorganic practices + panchagavya spray @ 3% at 30, 40 and 50 DAS recorded highest average bulb weight of 10.56 g.

P-52

Role of ecofriendly botanicals in the control of *Spodoptera litura* (Fab.) larvae in Chilli

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A study was undertaken to find out the toxic effects of crude aqueous leaf extracts of *Clerodendron inerme* (Verbenaceae) on one of the important lepidopteran pest asian armyworm, *Spodoptera litura* on Chilli (*Capsicum annuum* L.). Extracts at different doses *viz*., 1, 2, 3, 5, 7.5, 12.5, 15 and 17.5 per cent were tested against *S. litura* following the treatment on fourth instar larvae. All the different concentrations showed insecticidal activity in a dose dependent manner. Results demonstrated the higher percentage mortality during prepupal and pupal stage than that of during the fourth to sixth instar larval stages. The results of the percent total mortality (larval, prepupal, pupal and adult) revealed positive relationship between the percent concentrations of extract vs the mortality. It was seen that the percent total mortality was progressively increased from 1 percent treatment to 12.5 percent concentration. Thereafter the percent mortality i.e. 15 and 17.5 percent treatment, the total percent mortality remained almost 87 to 88 percent. Results of adult emergence inhibition indicated that the EI_{50} of *C. inerme* was more effective at 3.16 percent. Interestingly the calculated EI_{90} value was 30.98 percent. This plant has the potential to serve as an alternate biopesticide in the management of lepidopteron pests in chilli and other crops.

P-53

Evaluation of metaflumizone 22%SC against chilli fruit borer

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New insecticides *viz*., Metaflumizone 22% SC @110,165,220 g a.i/ha, Spinosad 45% SC@75g a.i/ha, Fipronil 5% SC@50 g a.i/ha, Thiodicarb 75% WP@750 g a.i/ha, Carbaryl 50% WP (Std Check) @1000 g a.i/ha were evaluated in the field against chilli fruit borer, *Helicoverpa armigera* (Hubner), during kharif season, 2010-11 at Main Agriculture Research Station, University of Agricultural Sciences, Dharwad. The results revealed that out of five insecticides evaluated, Metaflumizone 22% SC @ 220 g a.i./ha recorded lowest larval population of *H. armigera* (0.23/plant) which was on par with Metaflumizone 22% SC @ 165 g a.i./ha and 110 g a.i./ha. These treatments were significantly superior to Carbaryl 50% WP (0.70 larvae/plant). The untreated check recorded highest larval population of 1.20/plant. Metaflumizone 22% SC @ 220 g a.i./ha recorded minimun fruit damage of 12.01% which was on par with the Metaflumizone 22% SC @ 165 g a.i./ha (12.53%) and Metaflumizone 22% SC @ 110 g a.i./ha. These three treatments were significantly superior to all other treatments including the standard check, Carbaryl 50% WP (42.29%). The untreated check recorded highest fruit damage of 56.09 per cent which was significantly inferior to all other treatments. Highest green chilli fruit yield of 31.98 q/ha was recorded in Metaflumizone 22% SC @ 220 g a.i./ha being on par with Metaflumizone 22% SC @ 165 g a.i./ha. These two treatments were significantly superior to all other treatments. The Carbaryl 50% WP (standard check) recorded 22.35 q/ha. However, lowest yield of 14.07 q/ha was recorded in untreated check. Based on the results, it can be concluded that metaflumizone 22% SC @ 220 g a.i./ha and 165 g a.i./ha were found superior in reducing the larval population, fruit damage and in increasing the chilli fruit yield.

P-54

Evaluation of fungicides for the management of anthracnose disease of black pepper in the nursery

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Anthracnose caused by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc. is an important foliar disease of black pepper in the nurseries. A nursery trial was undertaken to study the efficacy of different fungicides against anthracnose disease. Three noded cuttings were made from the runner shoots with linear necrotic lesions caused by the pathogen. The cuttings were dipped in different fungicides *viz*., hexaconazole, propiconazole, metalaxyl + mancozeb, Bordeaux mixture, copper oxychloride, carbendazim and carbendazim + mancozeb at recommended concentration for 30 minutes. The treated cuttings were planted in polybags and observations on disease incidence were recorded 45 days after planting and repeated at 7 days interval for a period of one month. The combination product of carbendazim + mancozeb was found to be more promising as newly emerged leaves were free from the disease and also the treatment could delay the disease development by 15 days.

P-55

Leaf skipper incidence on turmeric

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In the experimental plot a leaf skipper – *Udaspes folus* (Cramer) a leaf eating caterpillar was observed feeding on foliage of turmeric. The incidence was noticed every year from August and attains peak during September to October month, thereafter the incidence declined. It was also observed that this pest was feeding on ginger raised in mulberry plantation. The caterpillar is dark green in colour with black head, it rolls the leaf margins inward and caterpillar remains in folded leaf and continues feeding from the margin leaving only midrib. Once the leaf is exhausted it moves to another leaf of a same plant. The damaged leaf looks as if it is cut by scissor irregularly. The larval period varies from 12-21 days and the full grown larva is about 36 mm long and pupates on the under surface of leaf by making silken web. Pupal stage lasts for about a week. Adult is medium sized with 4-5 cm wingspan. It is black with a large white spot on the upper side of the hind wing and several smaller white spots on the forewing. The underside of its wings is mostly white with brown edges and spots. The adults were found flying in turmeric plantation during morning and evening time. The female normally sits on the underside of the leaf and lays a single egg. The egg is reddish and appears smooth and dome shaped. It lays about 2-3 eggs/plant and hatches in 3-4 days. Total life cycle was completed in 28-35 days.

P-56

Growth and yield parameters of turmeric as influenced by intercropping in paired row mulberry plantation

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A field experiment was conducted under irrigated conditions to study the impact of turmeric intercropping in paired row [(60+120) x 30 cm] of V-1 mulberry under Integrated Nutrient Management. Generally mulberry is grown with wider spacing. The space available between the rows can be better utilized for intercrops. Turmeric crop is usually planted in the ridges and furrows method at a spacing of 45 cm apart and mother rhizomes were dibbled by the side of ridge at 22.5 cm apart. The recommended dose of fertilizers and manures to mulberry was used for both the crops. Observations were made on plant height (65-96 cm), number of leaves/plant (8-14), weight of fresh rhizome/plant (600- 875 g), weight of mother rhizome (150- 205 g), number of primary fingers, secondary fingers, spread of rhizomes and dry weight of rhizome was analyzed. The growth and yield parameters of turmeric were more in sole crop compare to other treatments. From this it is revealed that there is no negative effect of inter cropping turmeric on mulberry and cocoon production and also turmeric yield.

P-57

Studies on mulberry based ginger intercropping system

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In the present study an attempt was made to take up ginger as an intercrop in mulberry plantation in ridges and furrows method in paired row system of mulberry plantation under irrigated condition. Mulberry was pruned at a height of 60cm above the ground level during April month and ridges and furrows where made in between two paired rows of mulberry having 120 cm spacing. Ginger was planted on the sides of the ridge in mulberry plantation during first week of May mulberry provides partial shade and ginger comes up well in partial shade. Subsequently mulberry was pruned at height of 60cm from ground level at an interval 45 days for rearing of silkworm to produce silk cocoons. There was no negative effect of intercropping ginger on mulberry, cocoon production in intercropping system and also on ginger yield. The ginger yield was 2.5 q/ha. From the study it can be concluded that two rows of ginger can be grown in each paired row of mulberry having 120 cm spacing without hindering the intercultural operations to both the crops.

P-58

Molecular diversity of *Phytophthora* isolates from black pepper through ITS Sequence analysis

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Molecular diversity of 41 *Phytophthora* isolates from black pepper (*Piper nigrum* L.) was studied by sequencing the Internal Transcriber Spacer (ITS) region. The ribosomal DNA region containing the ITS region ITS 1 and 2 and the 5.8S rRNA gene, was amplified with the universal primers ITS 6 and ITS

4. The sequence data of these amplified fragments were obtained using ABI DNA sequencer. BLAST searches for ITS rDNA from these sequences indicated that 17 matched with *P. capsici,* 21 matched with both *P. capsici* and *P. tropicalis.* Eleven of these isolates also showed sequence similarity with other species of *Phytophthora viz*., *P. siskiyouensis* and *P. mengei*. Two isolates namely 08-04 and 98-95 showed sequence similarity of 99% with both *P. nicotianae* and *P. parasitica.* One isolate 99-188b matched 98% with *P. citrophthora* and *P. colocasiae.* All the hits had an E of value 0.0 and the query coverage ranged from 98-100%. The dendrogram constructed with ITS sequence data divided the isolates into two major clusters. Cluster 1was the major one with three subclusters. The isolates which showed maximum sequence similarity with *P. capsici* were grouped together and the isolates that showed maximum sequence similarity with *P. tropicalis* formed a separate group. The present study indicates that the *Phytophthora* isolates from black pepper showed sequence similarity predominantly with *P. capsici* followed by *P. tropicalis.* The study confirms the diversity among the isolates and involvement of more than one species infecting black pepper. The study confirms the diversity among the isolates and the involvement of *P. nicotianae* and *P. citrophthora* infecting black pepper.

P-59

Reaction of chilli genotypes against mites and thrips under natural conditions

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Evaluation of 80 chilli accessions to mites [*Polyphagotarsonemus latus* (Banks)] and thrips [*Scirthothrips dorsalis* (Hood)] infestation was done under natural condition during *kharif* season. Results indicated that sixteen accessions are resistant while fourteen are susceptible to thrips. The promising genotypes with resistant reaction to both the pests included IC 324894, Pant C-1, DCA-7, DCA-11, DCA-40 and Arka Lohit. DCA-4, DCA-8, DCA-41 and Byadagi Kaddi were found susceptible to mites. The genotypes IC 538029, IC 361908, Surajmukhi, DPCH-07-01, DCA-9, DCA-16, DCA-25, DCA-26, DCA-29, DCA-36, DCA-41, DCA-43, DCA-46 and Byadagi Kaddi were severely damaged by the pests. As many as 50 and 45 genotypes were found to be moderately resistant to thrips and mites, respectively with score between 11 to 25.

P-60

Effect of different seed rhizomes on growth, yield and quality of turmeric

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Investigations on the effect of different seed rhizomes on growth, yield and quality of turmeric (*Curcuma longa* L.) genotype CL 101 were carried with seven treatments *viz*., (T1) half cut mother rhizomes, (T2) whole mother rhizomes, (T3) daughter rhizome with Single bud, (T4) daughter rhizome with two buds, (T5) daughter rhizome with three buds, (T6) daughter rhizome with four buds (T7) whole daughter rhizomes with five buds. The study revealed that the plant height, number of leaves per plant, leaf area, leaf area index and number of tillers per plant were significantly higher when whole mother rhizomes were used as planting material compared to whole daughter rhizome used as control. Among the yield components, the number, length, girth, fresh and dry weight of mother, primary and secondary rhizomes were significantly higher when whole mother rhizomes were used than the other seed rhizomes.

The whole mother rhizomes produced higher fresh rhizome yield (29,000 kg/ha) compared to control (28,560 kg/ha). The quality parameters *viz*., curcumin, oleoresin and essential oil content were found to be higher in the whole mother rhizomes. Thus from the present study, it was observed that (T2) whole mother rhizome differs significantly from other treatments for all the plant growth characters. This was closely followed by (T7) whole daughter rhizome which remained on par with T2.The cost benefit ratios for the two treatments were same (3.20). Therefore for obtaining higher yield and quality, it is recommended to use the whole mother rhizome and daughter rhizome with five buds as seed material.

P-61

Effect of zinc fertilization on quality profile of ginger

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Field experiments were conducted for three consecutive years (2008-09. 2009-10, 2010-11) in zinc (Zn) deficient soil with the objective of studying the variation in quality and oil composition of ginger due to incorporation of Zn in the fertilizer schedule. The crop was manured as per the recommended package of practice (POP). Then treatments consisted of recommended POP without zinc, POP + 5 kg Zn/ ha as zinc sulphate, POP + 10 kg Zn/ha as zinc sulphate. The treatments were imposed at 45 DAP. The results showed that application of Zn increased the yield of ginger from 7.72 to 9.57 kg/ $3m^2$ bed suggesting a 23% increase. Zn fertilization also increased the oil, oleoresin, β-sesquiphellandrene, farnasene, camphene and z-citral contents of ginger oil. Contrarily, Zn fertilization decreased zingiberene, α-pinene, α-curcumene and 1, 8 cineol contents of ginger oil. Though Zn fertilization increased the fiber content there was no statistical significance. There was also no significant difference in β-phellandrene and citral contents of ginger oil due to Zn fertilization. The fiber content varied from 3.05 to 4.40%, oil content from1.33 to 1.73% , oleoresin from 3.35 to 5.41%, zingiberene from 13.1 to 21.8%, α-pinene from 0.67 to 2.23%, β-sesquiphellandrene from 5.92 to 10.20%, farnasene from 5.58 to 11.1%, camphene from 33.06 to 5.36%, z-citral from 3.73 to 6.54%, α- curcumene from 5.32 to 7.70%, 1,8 cineol from 2.70 to 5.29%, β- phellandrene from 1.87 to 4.18% and citral from 5.03 to 6.54%.

P-62

Growth of lemon balm as influenced by spacing and integrated nutrient management

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An experiment was carried out to standardize optimum spacing and to work out the integrated nutrient management for growth in *Melissa officinalis*. The maximum plant height (44.26 cm) with the application of 100 per cent inorganics at closer spacing of 30 m x 45 m (F_1S_1) was significantly superior to other treatments. The wider spacing (60 cm x 45 cm) produced more number of primary branches as compared to closer spacing (30 cm x 45 cm) in main and ratoon crops. The plants spread at wider spacing (60 cm x 45 cm) recorded significantly more spread (1215.6 cm^2, 988.2 cm^2, 943.7 cm^2 and 1048.8 cm^2 respectively), in the first three harvests and on an average of three harvests, while the minimum plant spread was observed in plants spaced at closer distance (1919.3 cm^2, 846.8 cm^2, and 669.5 cm^2, respectively).

P-63

Influence of spacing and integrated nutrient management on herbage yield in lemon balm

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An experiment was carried out to standardize optimum spacing and to work out the integrated nutrient management for growth in *Melissa officinalis*. The application of different levels of organic and inorganic nutrients showed significant influence on herbage yield per plant, per plot and per hectare in main crop as well as in ratoon crop. The application of nutrients with 50 per cent inorganic and 50 per cent organic combination produced a herbage yield of 173.71 g, 150.53 g per plant which was *on par* with 3:1 combination of inorganics and organics and 100 per cent inorganic nutrients, while the minimum herbage was obtained in the plants treated with 100 per cent enriched farm yard manure alone.

P-64

Exploitation of yield potential of coriander with organic and inorganic nutrient management

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The experiment consisted of 14 treatments *viz*., T_1- Control, T_2- 100% recommended dose (RD) through inorganic fertilizer (IOF), T_3 –100% RD through FYM, T_4- 100% RD through poultry manure, T_5- 100% RD through vermicompost , T_6-100% RD through neem cake, T_7 – 50% RD through FYM and IOF, T_8- 50% RD through poultry manure and IOF, T_9- 50% RD through vermicompost and IOF, T_{10}- 50% through neem cake and IOF, T_{11}- 75% RD through FYM and 25% through IOF, T_{12}- 75% RD through poultry manure and 25% through IOF, T_{13} -75% RD through vermicompost and 25% through IOF and T_{14} – 75% RD through neem cake and 25% through IOF. Recommended package of practices were followed for raising the crop. The recommended dose of fertilizer was 60 kg N and 45 kg P_20_5/ha. The application of organic sources as per nutrient management treatments was applied on the basis of their nitrogen content. Pooled data over two years indicated that treatment T_9 produced significantly highest plant height over T_1, T_6, T_3, T_4 and T_{14}. Treatment T_9, being at par with T_2 and T_8, recorded significantly higher yield attributes and seed yield of coriander over other treatments. Similarly treatment T_9 (50% RD through vermicompost and 50% through inorganic fertilizer) also recorded significantly highest net return except T_2 over all other treatments.

P-65

Studies on survey for *Erythrina* gall wasps on different *Erythrina* species in Karnataka

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In recent years, *Erythrina* gall wasp, *Quadrastichus erythrine* is causing severe damage on *Erythrina,* a popular standard for most of the vine crops in Karnataka. The present survey was undertaken during 2008-2010, in both black pepper and betel vine growing areas of Karnataka. The roving method of survey technique was used for sampling in all the places. For sampling ten localities were selected in each black pepper and betel vine growing regions in each district and from each locality, three fields were considered randomly. The results revealed that the maximum area of betel vine gardens were with *Erythrina indica* as standards and all the gardens showed incidence of *Erythrina* gall wasp. Most of the growers were using *Sesbania* sp. and drumstick plants as alternate standards for betel vine crop. In black pepper growing tracts of Malnad region, three species *viz*., *Erythrina indica, E fusca* and *E. subumbrans* were noticed. The *Erythrina indica* and *E fusca* occupied Coorg and all the three species were noticed in parts of Hassan, Chickamagalur and in Shimoga districts. The incidence of pest was recorded in two species, *Erythrina indica* and *E fusca* in all the places and there was no incidence on *Erythrina subumbrans*. Further, all the three species of *Erythrina* were screened against this pest intensively under field and poly house condition by growing all the three species together but no incidence was recorded on *Erythrina subumbrans*. The study indicated that *Erythrina subumbrans* (Kassk.) Merrill can be utilized as alternate standard for black pepper and betel vine.

P-66

Management of hairy caterpillar in small cardamom

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The present experiment was conducted to study the seasonal incidence of hairy caterpillar *Eupterote canarica* Moore on Mudigere-2 variety during 2008-09 and 2009-10. The pest population was correlated with abiotic factors. Also, neem oil (4 mL), Econeem plus (4 mL) and fish oil rosin (4 g) were compared with three insecticides Imidacloprid, Acetamiprid and standard check Carbosulfan) for the management of hairy caterpillars. The first spray was given during the onset of pest infestation and second spray was taken up 20 days after the first spray. The observations were recorded a day before, 15, 30 and 45 days after first treatment. The data was finally pooled and analyzed statistically. Results indicated that, the incidence of hairy caterpillars ranged from 0.0 to 5.51. There were two peaks of infestation and the first peak was noticed during September and October. The population of hairy caterpillar exhibited a positive correlation with maximum relative humidity (r=0.41), rainfall(r=0.49) and minimum temperature (r=0.50) and negative correlation with temperature (maximum) (r=0.78), sunshine hours (r=-0.7). Among treatments, insecticidal treatments *viz*., Acetamiprid (0.35g), Imidacloprid (0.5 mL) and carbosulfan (2 mL) were effective compared to three organic insecticides *viz*., neem oil (4 mL), Econeem plus (4 mL) and fish oil rosin soap (4g). Acetamiprid (0.35g) recorded lowest number of hairy caterpillars. The results indicated that the botanical insecticides are less effective compared to chemical insecticides.

P-67

Evaluation of different concentrations of flubendiamide against cardamom thrips and capsule borer

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The objective of the present study was to evaluate different concentrations of Flubendiamide 480SS against thrips (*Sciothrips cardamomi* Ram), shoot and capsule borers (*Conogethes punctiferalis*) of cardamom and compare with standard check Carbosulfan. The experiment had seven treatments *viz*., flubendiamide @10, 12.5 and 15mL per 100 lit of water, quinalphos 2mL, profenophos @1.5mL per lit and compared with carbosulfan @ 2 mL per lit sprayed during March (Prior to flowering), followed by three sprays with Phosalone 2mL per lit of water during April, May (flowering) and August (capsule formation) as spray. The results indicated that the thrips population ranged from 0.98 to 17.8. The maximum population was recorded during February-April, The thrips population exhibited a significant positive correlation with maximum temperature (r = 0.864) and sunshine hours (r=0.629). A significantly negative correlation was recorded between thrips population with rainfall (r= -0.313), relative humidity (r= -0.563) and minimum temperature (r= -0.278). The quality analysis of different graded capsules indicated lowest oil content (4.56%) in maximum thrips damaged capsules compared to healthy (5.15%) capsules. The 1.8–cineole (37.95%) content was high in damaged capsules compared to healthy capsules (34.8%) whereas reverse trend was observed in case of α–terpenyl acetate. More than 33 per cent loss in weight of capsules was recorded in damaged capsules (16.55g) compared to healthy capsules (23.15g).

P-68

Evaluation of black pepper germplasm against *Phytophthora* foot rot under arecanut cropping system in central Western Ghats of Uttara Kannada, Karnataka

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An attempt was made to evaluate germplasm of black pepper (*Piper nigrum* L.) against *Phytophthora* foot rot (*Phytophthora capsici* Leonian.) in plantations under natural conditions for effective integrated management measures with use of tolerant germplasm, systemic fungicides and biocontrol agents. Among 45 germplasms of black pepper evaluated against the disease, a few accessions recorded minimum disease incidence *viz*., Ademane (2%), BPS-2, (2%), BPS- 4 (3%) and P-24 (4 %). Moderate disease incidence was observed in seven genotypes (6 to 8 %). Twelve genotypes showed highest incidence of the disease (22 to 38 %).

P-69

Effect of time of planting on the incidence of phytophthora rot in black pepper nursery

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An experiment was conducted for two seasons to assess the influence of time of planting of pepper nursery on the incidence of *Phytophthora capsici.* Time of raising nursery had significant effect on sprouting of pepper cutting. Even though there were slight variations in sprouting, the highest sprouting was recorded when pepper cuttings were planted between third and sixth fortnights (February to March). Thereafter, it was found reduced and minimum sprouting in those planted during the tenth fortnight. Significant variation on the production of leaves was also noticed with planting intervals. Number of leaves was maximum when the vines planted during fourth and sixth fortnights, while it was reduced when time of planting delayed. Similar trend was noticed in the case of height of vines also. Production and length of roots also varied significantly with time of planting. Maximum number of roots was produced when planted during third and sixth fortnights. Marked variations in length of roots were also noticed when planted during the third and sixth fortnights. The time of production of root of pepper cuttings had significant effect on the incidence of *Phytophthora* rot caused by *Phytophthora capsici*. In general, late months planted cuttings, the incidence of *Phytophthora* rot was more when compared to

those planted during February and March. Hence raising of pepper nursery during February-March is the most ideal for better growth of vine and less disease incidence.

P-70

Eco-friendly methods for the management of root rot in fenugreek

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To evolve eco friendly management of fenugreek root rot caused by *Rhizoctohia solani,* field trials were conducted. The pooled analysis of the three seasons data showed that the seed treatment with *Trichoderma viride* @ 4g/kg of seed + soil application of *Trichoderma viride* @ 5 kg/ha + soil application of neem cake @ 150 kg/ha recorded the Percent Disease Index (PDI) of 23.1 against 65.5 PDI in the control which accounted for the disease reduction of 64.7 percent with the maximum yield of 595 kg/ha and the CB ratio of 1:3.9 It was on par with seed treatment with *Trichoderma viride* @ 4g/kg of seed + soil application of *T. viride* @ 5 kg/ha (T2) which reduced the disease incidence by 62.3 percent (24.7 PDI) with yield of 580 kg /ha and the C:B ratio of 1:4.1. Hence seed treatment with *T. viride* @ 4g/kg + soil application of *T. viride* @ 5kg/ha is a cost effective eco friendly management strategy for fenugreek root rot.

P-71

Management of foliar diseases in turmeric using new fungicide molecules

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Among the fungal diseases, leaf spot caused by *Colletotrichum capsici* (Syd) and leaf blotch caused by *Taphrina maculans* (Butler) are the major foliar diseases of turmeric. Taking into account the economic importance of the disease, the present study on the efficacy of newer fungicide molecules would be necessary to step up and stabilize the productivity in this crop. A field trial was laid out with nine treatments in RBD with three replications during the years 2008-2011. The pooled mean analysis of three years data revealed that T6 (Foliar spray – Propiconazole (0.1%) on 45 and 90 days) was the best treatment in reducing the leaf spot intensity to 19.33 PDI and leaf blotch intensity to 13.34 as compared to untreated control (61.56 PDI). This treatment was on par with T8 treatment (Foliar spray with Carbendazim + Mancozeb (0.1%) on 45 and 90 days.) The T6 treatment also recorded the maximum yield of 38.92 t ha^{-1} with the highest C: B ratio of 1:4.60 followed by T8 treatment with yield of 34.44 t ha^{-1} and the CB ratio of 1:3.92 as compared to control (23.51 t ha^{-1}).

P-72

Survey and surveillance of turmeric diseases in Tamil Nadu

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A field survey on turmeric diseases in conventionally turmeric growing areas of Tamil Nadu was carried out to assess the disease severity in hot spot areas of the diseases during the years 2007-2011. The disease survey was conducted in turmeric growing areas of different districts viz., Coimbatore, Erode, Thirupur, Salem and Namakkal districts in pure crop as well as in mixed cropping system. In each district, more than ten places were surveyed and the disease incidences were recorded. In Coimbatore, totally 15 places were surveyed for the diseases in different cropping system. The leaf spot intensity ranged from 28.20–54.20 PDI, the leaf blotch intensity ranged from 12.03-28.20 PDI and the rhizome rot incidence ranged from 8.0-16.0%. In Erode district, 17 places were surveyed. The leaf spot intensity ranged from 28.00- 56.60 PDI, leaf blotch ranged from 14.0 PDI–36.0 PDI and the rhizome rot incidence ranged from 10.00–30.0%. In Namakkal district, survey was conducted in 12 different locations. The leaf spot intensity ranged from 28.32 PDI–42.30 PDI, leaf blotch ranged from 18.67–24.67 PDI and the rhizome rot incidence ranged from 12.0-14.0%. In Salem district the survey was conducted in eleven places and the leaf spot intensity ranged from 32.30–48.32 PDI, leaf blotch ranged from 20.21–26.67 PDI and the rhizome rot incidence ranged from 10.00-12.00%. In Tirupur district, totally ten places were surveyed. The leaf spot intensity ranged from 28.20–44.00 PDI, leaf blotch intensity ranged from 24.60–36.13 PDI and the rhizome rot incidence ranged from 10.00-12.00%. In general, the leaf spot intensity was minimum when grown as pure crop compared to mixed crop with chillies or other crops in all districts.

P-73

The inoculation effect of phosphate solubilizing microorganisms on growth and yield of chilli

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Phosphate solubilizing microorganisms (PSM) from major chilli (*Capsicum annum*. L) growing areas of Upper Krishna Project (UKP) command area were isolated from rhizosphere soils. Fifty phosphate solubilizing bacteria and fifty phosphate solubilizing fungi were isolated from fifty chilli rhizosphere soil and incubated on Pikovskaya's agar for bacteria and Pikovskaya's agar supplemented with rose bengal for fungi. Two efficient PSMs were selected based on *in vitro* P-solubilization. The PSB and PSF isolates P*i* released at 6 DAI ranged from (PSB-Y-9) 85.05 to 145.03 mg/l and (PSF-DD-3) 82.02 to 157.30 mg/l in Pikovskaya's broth. They were tested for their efficacy to solubilize different P sources in pot culture experiment and chilli as a test crop. Pot experiment showed that the inoculation of PSMs significantly increased plant height, number of branches, P concentration, and root biomass, root and shoot dry matter content, number of fruits per plant and green chilli yield over SSP control, RP control and absolute control.

P-74

Bio efficacy studies of KOCIDE2000 on chilli anthracnose caused by *Colletotrichum capsici*

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The experiment was conducted to know the bio efficacy of KOCIDE 2000 against chilli anthracnose (*Colletotrichum capsici*). Incidence was recorded on red chillies by using 1-9 scale and converted into Percent Disease Index (PDI). Results revealed that KOCIDE-2000 at 87.5 gai/ha (lowest tested concentration) recored PDI of 20.75 and remained significantly superior to untreated control of 39.29. It was observed that 437.5 gai/ha recorded 5.10 on par with chemical check propiconazole @ 1% of 4.25 PDI. The treatments 250,500,750gai formulated product/ha were on par with each other. With respect to yield parameters maximum yield was observed in 1250g formulated product, 1752 kg/ha , and it is on par with propiconazole @ 1% 1760 kg/ha when compared to untreated control of 850 kg/ha. From these studies we can conclude that KOCIDE-2000 is an efficient chemical to reduce the disease with highly significant increase in yield without showing any phytotoxicity and other harmful effects.

P-75

Standardization of *Agrobacterium* mediated transformation of black pepper

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Standardization of Protocols for somatic embryogenesis and plant regeneration in black pepper (*Piper nigrum* L.) and *Agrobacterium* mediated genetic transformation in black pepper using a PR 5 gene 'Osmotin' is reported in the study. Plants could be successfully regenerated from tender leaf, shoot tip and hypocotyls explants of both mature and juvanile tissues using MS/ WPM supplemented with with BA (0.05-1 mgl^{-1}) and TDZ (0.05-1 mgl^{-1}). Somatic embryogenesis was also induced successfully from tender leaf explants of *in vitro* established mature tissues using the same medium. Successful transformation of black pepper using *Agrobacterium* strain pGV 2260 which carries a PR 5 gene 'Osmotin' under the control of CaMV 35 S promoter. About 50 transgenics were obtained and planted in the glass house. The transgenicity was confirmed in 4 of the transgenics using osmotin and npt II specific primers. The transgenics showed differential expression of osmotin and one of them did not take up infection even after 72 hours after inoculation with *Phytophthora capsici*.

P-7

Turmeric a suitable intercrop in paired row system of mulberry plantation

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An integrated approach to boost cultivation of turmeric and mulberry was taken up taking into account the perennial nature of mulberry and the ability of the turmeric to come up well in partial shade condition. An effort was made to fit the turmeric crop without affecting the intercultural operation of both the crops and their yield. The ridges and furrow method of turmeric planting was filled in between the two paired rows of mulberry during second week of May soon after middle pruning of mulberry garden. From the study it is observed that two rows of turmeric in between two paired rows of mulberry having a spacing of 120 cm and three rows of turmeric in mulberry of spacing 150 cm is suitable. The mulberry is pruned at an interval of 45 days to take up shoot rearing of silkworm. There is no negative effect of inter cropping turmeric on mulberry and cocoon production and also turmeric yield. From the study it is observed that turmeric is a suitable high value inter crop in mulberry plantation and some farmers are already practicing this system in Northern Karnataka to increase their farm income.

P-77

Intercropping of garlic in paired row system of mulberry plantation

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In the present study an attempt was made to take up garlic as an intercrop in paired row system of mulberry plantation under irrigated condition. The experiment was in established paired row system of V-1 mulberry plantation. The mulberry garden was pruned at a height of 60cm above the ground level during first week November and the land was ploughed and harrowed in between the paired rows of mulberry. The garlic cloves of local variety were dibbled at a spacing of 15 x 7cm in flat bed method and the crop was irrigated weekly interval. It was observed that garlic comes up well in paired row system of mulberry plantation. There is no negative effect of intercropping garlic on mulberry, silkworm and their yield. It can be concluded that garlic can be taken successfully as an intercrop in paired row system of mulberry plantation during rabi season in irrigated condition.

P-78

Twister: a new disease in garlic

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Climate change has brought anomalies in garlic disease leading to emergence of new disease “Twister”. This disease vernacularly called as *Haavu suruli roga*. Recently, twister disease has become epidemic that caused yield losses of 5 to 30% in farmer’s fields of Dharwad, Gadag and Belgam districts. This disease has shown positive correlation with rainy fall, during July-August. Disease symptoms consist of chlorosis followed by curling and twisting of leaves and abnormal elongation of the neck region, subsequently showing twisting of entire plant. Survey reports revealed that, maximum incidence was noticed in Vannur village of Bailahongal taluk, Belgam district with 45 percent disease incidence. While it was lowest in Savadatti taluk (20 percent incidence). Acervuli of *Colletotrichum gloesporoides* were detected in lesions of the neck region, as well as on leaf blades. Repeated isolations from leaves and the neck region of symptomatic plants plated on potato dextrose agar produced fungal colonies identified as *Fusarium oxysporum* and *Colletotrichum gloesporoides*.

P-79

In vitro evaluation and identification of potential rhizospheric actinomycetes for the biocontrol of *bacterial wilt* of ginger

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Antibacterial actinomycetes isolated from different ginger growing tracts of Kerala and Karnataka were evaluated for their effect on *Ralstonia solanacearum*, the bacterial wilt pathogen of ginger. The cultures were isolated using actinomycetes isolation agar. A total of 30 actinomycetes were isolated and 12 colonies having distinct colony morphology were shortlisted. They were subjected to preliminary evaluation *in vitro* by perpendicular streak method. The degree of antagonistic activity varied greatly among the isolates and certain isolates were highly inhibitory against the pathogen. Based on inhibition, nine isolates were shortlisted and characterized morphologically and by molecular methods by rpoB (RNA polymerase beta subunit) gene sequencing. Sequence information showed that all the potential isolates belonged to *Streptomyces* species. Act2 was identified as *Kitasatospora setae*, which closely resembles *Streptomyces* except for the cell wall composition and the 16S rDNA sequence. These potential actinomycetes can be exploited for the biological control of bacterial wilt in ginger.

P-80

Sensitivity of fungicides against *Colletotrichum gloeosporioides*, the incitant of anthracnose disease of black pepper

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Efficacy of ten fungicides *viz*., benomyl, propiconazole, hexaconazole, metalaxyl + mancozeb, Bordeaux mixture, chlorothalonil, triadimefon, carbendazim, carbendazim + mancozeb and mancozeb were evaluated under *in vitro* conditions against *C. gloeosporioides* by employing poisoned food technique. The fungicides were tested at six different concentrations (0.05%, 0.125%, 0.25%, 0.5%, 1% and recommended dose) and percent reduction in the radial growth of the pathogen was computed after seven days of incubation period. All the fungicides tested inhibited growth of the pathogen under laboratory conditions. Among the fungicides evaluated, propiconazole and the combination product of carbendazim + mancozeb completely inhibited the growth of the pathogen at all the concentrations tested.

P-81

Effect of the number of rejuvenating shoots on the growth and yield of cinnamon

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In cinnamon higher productivity depends on the rejuvenation growth after coppicing. So to induce maximum productivity there is a need to standardize the optimum number of rejuvenating shoots that should be left per bush. An experiment was undertaken in cinnamon by maintaining the coppicing height uniformly at 30 cm from the ground level. Each bush was maintained with four stumps. The number of young shoots which sprung up from the stump were trimmed and maintained in numbers of 2,4,6,8 and 10. Observations were recorded on the height, girth, leaf and bark yield of the rejuvenation growth. The results of the study revealed that the maximum bark yield (1.320 kg/tree/year) and life yield (5.40 kg/tree/year) was obtained in the treatment T_3 with six branches. More over this treatment also recorded the start coppicing interval of 426.9 days.

P-82

Integrated management of rhizome wilt of ginger with special reference to *Ralstonia solanacearum* (E.F. Smith) Yabuuchi *et al.*

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A field experiment on integrated management of ginger rhizome rot with special reference to *Ralstonia solanacearum* (E.F.Smith) Yabuuchi *et al* was conducted during kharif 2010. The results indicated that among the different treatments, rhizomes of ginger treated with Streptocycline at 0.5 g L^{-1} + Copper Oxychloride at 2.0 g L^{-1} + soil application of Carbofuron + drenching with Metalaxyl- MZ 1 g L^{-1} and drenching Streptocycline at 0.5 g L^{-1} of water twice at 20 days interval starting with initiation of the disease recorded very less incidence (20.70%) when compared to control (49.85%). The yield was also maximum in this treatment (224 q per ha) whereas in control, the yield was only 37.60 q ha^{-1}.

P-83

Pathogens associated with rhizome rot disease of ginger in different growing districts of Karnataka

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A roving survey was undertaken in different growing areas of Shimoga, Uttara Kannada and Haveri districts of Karnataka. Samples were collected from all the locations and analyzed for the association of different pathogens. We observed several pathogens including fungal, bacterial and plant pathogenic nematodes and numerous free living nematodes. In Shimoga and Uttara Kannada districts we recorded pathogens like *Pythium* spp, *Fusarium* spp, *Sclerotium rofsii*, bacterial pathogen *Rastonia soanacearum* and plant parasitic *Meoidogyne*. But in Haveri district we observed only *Sclerotium rolfsii* and *Ralstonia solanacearum*.

P-84

Effect of organic production techniques on quality parameters of leafy coriander

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Investigations on coriander (*Coriandrum sativum*) were carried out to find out the effect of organic inputs and biostimulants on coriander (leaf) with reference to quality attributes. The treatments consisted of basal organic inputs namely panchagavya, triacontanol and humic acid. The study revealed that, coriander showed better response to application of 15 t of farm yard manure along with foliar application of panchagavya 3% and humic acid 0.2% which significantly increased the quality parameters such as essential oil (0.070%), ascorbic acid (160.80mg $100g^{-1}$) and protein (3.063g $100g^{-1}$) content in the leaf during both seasons compared to control (0.052%, 153.79 mg $100g^{-1}$ and 2.182g $100g^{-1}$ respectively).

P-85

Efficacy of entomopathogenic nematodes against insect pests of ginger and their mass production

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The efficacy of eight native entomopathogenic nematodes (EPN), *Steinernema* (IISR-EPN 02, 03 and 06), *Heterorhabditis* (IISR-EPN 01) and *Oscheius* (IISR-EPN 04, 05, 07 and 08) were tested against hairy caterpillar, *Euproctis* sp. and larva and pupa of shoot borer *Conogethes punctiferalis* in ginger (*Zingiber officinale* Rosc.). Among the tested EPN, all isolates caused 100 % mortality to hairy caterpillar except, *Oscheius* (IISR EPN 08) which caused only 95 % mortality. *Heterorhabditis* (IISR-EPN 01), *Steinernema* (IISR-EPN 02) and *Oscheius* (IISR-EPN 07 and 08) caused 100 % mortality to shoot borer larvae followed by *Steinernema* (IISR-EPN 03), *Oscheius* (IISR-EPN 04 and 05and *Steinernema* (IISR-EPN 06). *Oscheius* (IISR-EPN 07) was the most virulent against the shoot borer pupa, causing 100 % mortality, followed by 67 % by *Steinernema* (IISR-EPN 02) and *Oscheius* (IISR-EPN 05). No mortality was recorded with *Steinernema* (IISR-EPN 03), *Oscheius* (IISR-EPN 04 and 08). Multiplication of infective juveniles (IJs) of EPNs was comparatively better in shoot borer larvae than hairy caterpillar. Maximum number (0.82 X 10^5 IJs/shoot borer larva) of infective juveniles was observed for *Steinernema* (IISR-EPN 02), followed by *Oscheius* (IISR-EPN 05) (0.73 X 10^5 IJs).Minimum number of IJs was recorded (in shoot borer larva) for *Steinernema* (IISR-EPN 03) and *Oscheius* (IISR-EPN 07) (0.10 x 10^5 and 0.12 x 10^5, respectively). Lowest multiplication was observed for EPNs in hairy caterpillar. Infectivity of these insects by EPN is being reported for the first time. This opens a new non chemical option for management of insect pests of ginger.

P-86

Biological management of rhizome rot complex disease of ginger

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Among production constraints rhizome rot complex caused by two different pathogens, fungus *Pythium aphanidermatum* and bacteria *Ralstonia solanacearum*, is responsible for reducing ginger production. Surveys were carried out during the months of September-October 2008-10 to assess the magnitude of losses due to this disease in different localities in promising varieties. Results indicated that Rio-De Janeiro recorded highest severity (25-50%) followed by Himachal (10-40%). In the field trial on integrated disease management of rhizome rot complex of zinger indicated that, pre-sowing rhizome soaking with a solution containing 0.05% streptocycline + 0.3% copper oxychloride for 20 minutes followed by soil application with FYM enriched *Pseudomonas fluorescens* (@ 5kg ton^{-1} of FYM) recorded least per cent disease incidence (15.70) when compared to control (51.63). The lower per cent disease incidence was also noticed in treatments where *Trichoderma harzianum* and *Pseudomonas fluorescens* @1kg ton^{-1} of FYM (16.90). When we consider the yield and benefit cost ratio, use of *Pseudomonas fluorescens* (@ 5kg ton^{-1} of FYM) was superior (101.2 q ha^{-1} with 1.43 C: B ratio).

P-87

Seed quality of chilli as influenced by biofertilizer, growth regulator and organic manure

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An experiment was conducted to study the effect of biofertilizer, growth regulator and organic manure on seed quality of chilli (*Capsicum annuum* L). Application of RDF + FYM at 25 t per ha recorded higher per cent germination (78.65) and higher field emergence (74.50) and was on par with the other treatment like RDF + vermicompost at 4 t per ha, RDF + VAM @ 1.5 kg per ha, RDF + *Azospirillum* at 500 g per ha, RDF + NAA (40 ppm) and RDF + ethrel (250 ppm). Whereas the root length (5.8 cm), shoot length (5.4 cm) and dry weight (4.0 g) were significantly higher with application of RDF + FYM at 25 t per ha, followed by RDF + vermicompost at 5 t per ha and was on par with RDF + VAM @ 1.5 kg per ha, RDF + *Azospirillum* at 500 g per ha, RDF + NAA (40 ppm) and RDF + etherel (250 ppm) and was higher than control.

P-88

Yield of chilli as influenced by integrated nutrient management in coastal region of Karnataka

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A field experiment was conducted during kharif 2009 to study the effect of integrated nutrient management on yield of chilli (*Capsicum annuum*) under rainfed conditions. Treatments and varieties varied significantly for the fruit yield per plant. Significantly highest fruit yield was noticed in RDF + FYM at 25 t per ha (907 kg/ha) followed by RDF + vermicompost at 5 t per ha (812 kg/ha) and was on par with RDF + VAM @ 2 kg per ha (742 kg/ha).

P-89

Cardamom shoot and capsule borer menace in Karnataka

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Recently, shoot and capsule borer *Conogethes punctiferalis* emerged as a severe pest of cardamom (*Elettaria cardamomum* L.) in Karnataka, Kerala and Tamil Nadu. At the early stage of the crop, the caterpillars of this yellow coloured moth bore into the core of the aerial stem resulting in the death of central spindle, which appears as characteristic dead hearts. At flowering, when the caterpillars attack the panicles and spikes it may lead to flower shedding and drying up of the attacked portions. At a later stage of the crop, the caterpillars bore into the capsules, feed on the seeds and make them hollow. The presence of excreta at the region of attack indicates presence of the caterpillars in the pseudostem, inflorescence and pods. Pest infestation is pronounced in three seasons *viz*., January-February, June and September-October. For an effective management of the pest, the insecticides have to be targeted on early stages of the larvae, which are usually present within 15-20 days after adult emergence in the field. Spraying fenthion 0.05% or monocrotophos 0.05% is recommended during the months of February-March and September-October.

P-90

Pollu beetle: A potential pest problem in black pepper

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Pollu beetle is the most destructive of black pepper (*Piper nigrum* L) in India and its incidence was reported to be 20-30 per cent. It attacks all varieties of pepper. Both the adults and grubs cause damage by boring into ripening berries making them hollow. Further they feed on growing shoot tips and the tender spikes. The total life cycle takes 39 to 50 days. The pest infestation is more serious in shaded areas in the plantation, also during September-October in the field. Better management practices includes, cultivation of pepper at higher elevations (3000-4500 feet above MSL), use of resistant varieties, soil tillage to expose the pupae and grubs to the natural environment for destruction, elimination of over-shaded condition by pruning branches of shade trees before the onset of monsoon, spraying of quinalphos (0.05%) during June-July and September-October and Neemgold (0.6%) during August, September and October. Integrated pest management schedules incorporating biological control and involving minimum use of pesticides would be advantageous.

P-91

Efficacy of potassium phosphonate in the management of *Phytophthora* foot rot of black pepper caused by *Phytophthora capsici*

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Phytophthora foot rot caused by *Phytophthora capsici* is the major constraint and serious disease affecting the vines mainly during the south-west monsoon. Experiments revealed that black pepper vines treated with potassium phosphonate (0.3%) + *Trichoderma harzianum* before onset of monsoon (May 2nd fortnight), during monsoon (July 1st week) and after monsoon (September 1st fortnight) recorded lesser grade for yellowing (0.51), defoliation (0.51) and mortality of vines (15.0 %) and resulted in more yield/vine (1.68 kg) followed by Bordeaux mixture spray (0.1%) + COC (0.1 %) drenching with yellowing grade (0.94), defoliation (0.78) and mortality of vines (21.25 %) and yield/vine (1.31 kg) while the control recorded 1.44 for yellowing, 1.63 for defoliation and 31.25 % of vine mortality and yield of mere 0.70 kg/ vine.

P-92

Efficacy of various fungicides in the management of *Colletotrichum* leafspot and Taphrina leaf blotch diseases of turmeric under Chintapalli conditions of Andhra Pradesh

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A variety of molecules were tested for their management potential against leaf spot caused by *Colletotrichum capsici* and leaf blotch caused by *Taphrina maculans* in turmeric. Among the treatments, rhizome treatment with propiconazole (0.1%) + foliar spray of propiconazole (0.1%) on 45 and 90 DAP recorded a lowest incidence (19.63%) followed by rhizome treatment with carbendazim (0.1%)+ Mancozeb (0.1%) + foliar spray of carbendazim + mancozeb (0.1%) on 45 and 90 DAP (21.2%) while control plots received an incidence of 49.8% infection of leaf spot. With respect to the leaf blotch, rhizome treatment with carbendazim (0.1%) + mancozeb (0.1%) coupled with foliar spray of carbendazim + mancozeb (0.1 %) on 45 and 90 DAP recorded a lowest incidence (17.23%) followed by foliar spray of carbendazim + mancozeb (0.1%) alone on 45 and 90 DAP (21.63%). Rhizome treatment with propiconazole (0.1%) + foliar spray of propiconazole (0.1%) on 45 and 90 DAP also recorded a low incidence (22.26%) compared to control (43.57%).

P-93

Organic management of wilt disease of cumin (*Cuminum cyminum*)

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The wilt of cumin (*Cuminum cyminum*) caused by *Fusarium oxysporum* f. sp. *cumini* is a major disease in Rajasthan. This pathogen survives in soil and leads to appear heavy disease incidence from year to year. The use of organic manure/cake and bio control agents for control of soil borne plant pathogens has been often considered as a good tool to manage the disease caused by them. Field trials were conducted to assess organic manures/cake in combination with *Trichoderma viride.* Soil application of neem cake 2t/ha with *Trichoderma viride* was most effective in reducing the disease incidence and increasing seed yield (427 kg/ha). It was at par with soil application of FYM (10t/ha) with *Trichoderma viride*. Soil application of neem cake or FYM along with talc based preparation of *Trichoderma Viride* (10^8CFU/g) 2.5 kg multiplied in 100 kg FYM may be applied just before sowing in furrow for an effective management of wilt disease of cumin.

P-94

Management of powdery mildew of coriander through botanicals and organics

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Treatment involving panchagavya was very effective with 11.85 percent powdery mildew disease incidence compared to 44.44 percent disease in control plot and it was statistically on par with wettable sulphur (8.88%). Although azardichtin (19.26%) and cow urine (21.48%) reduced the disease moderately yield wise they were on par with panchagavya (5.58 q/ha).Similar trend was observed during 2010-11 also wherein, Spraying with 5% panchagavya resulted in least disease incidence of 11.81 percent compared to control with 45.33 percent incidence. Mean yield over the years was also highest with panchagavya spray (5.67 q/ha) which was statistically significant compared to control and on par with treated check sulphur (5.87 q/ha).

P-95

Characterization and identification of black pepper mycoendophytes antagonistic to *Phytophthora capsici*

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In this study, seven endophytic fungal isolates of black pepper which showed biocontrol potential against the major pathogen of black pepper *P. capsici* were characterized morphologically and identified to various taxonomic levels using ITS- rDNA sequencing. Morphological characterisation of the isolates revealed both sporulating and non sporulating types. Among the seven isolates five were non-sporulating types and two were identified as *Fusarium* species. Both sporulating and non-sporulating isolates were identified based on the ITS rDNA sequence. The 5.8S gene and flanking internal transcribed spacer (ITS1 and ITS2) regions of rDNA were amplified and sequenced. The sequence analysis of the isolates showed maximum identity with *Annulohypoxylon nitens* (BPEF25 and BPEF38), *Daldinia eschscholzii* (BPEF41 and BPEF73), *Fusarium proliferatum* (BPEF72), *Fusarium moniliformae* (BPEF75) and *Ceriporia lacerata* (BPEF81). The occurrence of these mycoendophytes in black pepper system is a new report.

P-96

Influence of biochemical parameters on the settling behaviour of *Scirtothrips dorsalis* Hood on chilli leaves

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The experiment was conducted in laboratory to study the settling behaviour of *Scirtothrips dorsalis* Hood on chilli leaves. Free choice test was conducted with chilli plants treated with PGPR (*Pseudomonas fluorescens* Migula), PGR (Naphthalene Acetic Acid) and neem oil. The results from the present experiment showed that lowest population (0.66/leaf disc) of thrips were settled on *P. fluorescens* @ 5g/lit + NAA @ 10ppm + neem oil @ 30ml/lit followed by *P. fluorescens* @ 5g/lit + NAA @ 10ppm and NAA alone treated leaves. The highest populations (3.00) of thrips were settled on untreated check.

P-97

Impact of eco-friendly methods on chilli thrips *S. dorsalis* management

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The impact of PGR (Naphthalene Acetic Acid), PGPR (*P. fluorescens*) and neem oil with emulsifying agent (Khadi soap @ 1g/lit of neem oil) on population build up of *S. dorsalis* under greenhouse conditions on chilli cv. CO 4 was under taken. Potted plants (45 days old) inoculated with known number of pests were sprayed with respective treatments using hand sprayer. Treatments were imposed at 15 days after inoculation (DAI), 30 DAI and 45 DAI. Population of thrips was recorded at regular intervals after each treatment. Each treatment was replicated thrice with ten potted plants per replication. The treatments evaluated are T_1 - PGPR - *P. fluorescens* @ 5g lit $^{-1}$, T_2 - PGR - Naphthalene Acetic Acid (NAA) @10ppm, T_3 - Neem oil 3% @ 30 ml lit^{-1} , T_4 - $T_1 + T_2$ (5g lit^{-1} + 10ppm) T_5 - $T_1 + T_2 + T_3$

(5g lit $^{-1}$ + 10ppm + 30ml lit^{-1}), T_6 - Phosalone 35EC @ 2ml lit^{-1}, T_7 - Water spray @ 500 lit ha^{-1} and T_8 - Untreated check. The results on thrips population and yield showed that the lowest population (3.2 thrips/five plants) and highest yield (7529kg/ha) was noticed in *P. fluorescens* + NAA + neem oil sprayed pots followed by Phosalone @ 2ml/lit (4.6 thrips/five plants, 7262kg/ha) and *P. fluorescens* + NAA + neem oil (5.8 thrips/five plants, 6336kg/ha) when compared to untreated check (18.4 thrips/five plants, 4125kg/ha) respectively.

P-98

Effect of environmental factors on *Cercospora* leaf spot incidence in chilli

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The epidemiological studies of *Cercospora* leaf spot of chilli caused by *Cercospora capsici* was carried out during *kharif* 2008-09 and 2009-10 through simple correlation and multiple linear regression analysis to establish relationship between disease incidence and weekly weather parameters. In 2008-09, there was a maximum positive correlation with rainfall followed by number of rainy days, minimum temperature, relative humidity evening and maximum temperature with that of incidence of 45.48 per cent and RH morning was only negatively correlated. In 2009-10, there was a positive correlation between maximum and minimum temperature with disease incidence of 54.83 per cent whereas RH, rainfall and rainy days were negatively correlated. The coefficient of determinative value (R^2) was found to be 60 and 76 per cent in 2008-09 and 2009-10 respectively. Leaf spot incidence was positively correlated with minimum temperature (0.726) followed by maximum temperature (0.594), number of rainy days (0.384) and rainfall (0.237) which were reflected as the most influencing condition for disease development. The disease increased with increase or decrease in temperature, decreased with increase in RH and rainfall.

P-99

Cercospora leaf spot management in chilli (*Capsicum annuum* L.)

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In the present experiment, *Cercospora* leaf spot management study was taken up in cultivar *Byadgi kaddi* using three fungicides, two bioagents and a plant extract. Two sprays of each treatment were given at an interval of 10 days from the onset of disease. The per cent disease index (PDI) was recorded 10 days before and after each spray. The least PDI (11.67) was noticed in plots treated with propiconazole (0.1 per cent), which significantly differed with carbendazim (12.56) (0.1 per cent) spray followed by carbendazim + mancozeb (0.2 per cent). Among the bioagents spray (5%), *B. subtilis* resulted in 19.57 per cent incidence followed by *P. fluorescens* (20.49%). The neem seed kernel extract spray resulted in 21.29 per cent incidence and untreated plot had PDI of 36.40. Propiconazole recorded highest disease reduction of *Cercospora* leaf spot and produced highest dry chilli yield (22.80 q/ha) followed by carbendazim treated plots (21.27 q/ha).

P-100

Leaf yield in relation to soil fertility status of betelvine gardens in Guntur district of Andhra Pradesh

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A systematic investigation was conducted on soil fertility status to ascertain its impact on growth and yield of betel vine. Soil samples from thirty betelvine gardens were collected during survey (2006-2009), analyzed mechanically and chemically. All the soils were clayey loam in texture. The pH of the soil was alkaline (7.1 to 8.40). The EC ranged from 0.35 to 1.61 ds/m. The organic carbon content of the soil was in the range of 0.55 to 1.24%. The available nitrogen, phosphorus and potassium content ranged from 201 to 313 kg/ha, 10 to 60 kg/ha, 337 to 840 kg/ha respectively. The growth parameters *viz*., plant height (260.50 – 334.00 cm), number of laterals (15 - 34), internodal length (6.10-10.00 cm) and petiole length (4.90 – 8.00 cm) were also recorded in thirty betel vine gardens. The growth parameters *viz.,* number of laterals, internodal length, petiole length and soil parameters *viz.,* pH, EC and phosphorus were non significant and positively correlated with betel leaf yield, while plant height and soil nutrients *viz.,* organic carbon content, nitrogen and potassium were significant and positively correlated with leaf yield. Thus, this study showed that the leaf yield is directly dependent upon the soil fertility of the crop and the better management practiced by the farmers ensures higher yields.

P-101

Feasibility of inter cropping medicinal plants in black pepper garden

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A field experiment was conducted to assess the feasibility of cultivating medicinal plants in black pepper plantation. Medicinal plants such as *Adhatoda beddomei* (Chittadalodakam), *Desmodium gangeticum* (Orila) *Pseudarthria viscida* (Moovila), *Ayapana triplinervis* (Ayapana), *Pogostemon cablin* (Patchouli) and *Plumbago rosea* (Chetikoduveli) were intercropped in an established 15 year old black pepper plantation. These medicinal plants along with a control (sole crop of black pepper) formed the treatments. The results indicated that black pepper yield (2100 kg/ha) was higher under intercropping situation compared to sole crop (1675 kg/ha). In order to compare the system, intercrop yields were equated with black pepper yield and Pepper Equivalent Yield (PEY) was calculated. Among the medicinal plants, *Plumbago rosea* recorded maximum PEY (2100 kg/ha) followed by *Pogostemon cablin* (2000 kg/ha). Maximum net return of Rs 1,99,200 per ha was obtained from black pepper + *Plumbago rosea* followed by *Pogostemon cablin* (Rs 1,87,500/ ha). The benefit: cost ratio was higher for inter cropping with *Plumbago rosea* (3.5) followed by *Pogostemon cablin* (3.3) and *Ayapana triplinervis* (3.3).

P-102

Amplification, cloning and *in silico* prediction of full length elicitin gene from *Phytophthora capsici*, the causal agent of foot rot disease of black pepper

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Elicitins are family of small proteins secreted by *Phytophthora* which induce leaf necrosis in infected plants. Here we report the cloning of Elicitin gene from *P. capsici,* an Oomycete plant pathogen which causes significant damage to a broad range of host plants. Elicitin sequence was amplified using primers designed from the known Elicitin genes of other *Phytophthora* organisms based on their conserved motifs. The PCR amplified product size was about 256bp length and the BLAST analysis of the sequenced product shows perfect match with alpha-elicitin sequences. Subsequently, attempt was made to identify the complete gene characterization of elicitin gene from complete genome sequence of *P.capsici* by querying the amplified product against the genome. Local BLAST search against full genome identified complete coding sequence. Further sequence analysis identified promoter sequence, transcription start site, a leader signal sequence and a core elicitin domain with a conserved 6 Cysteine residues. In addition, the three dimensional structure of capsicein was modelled and the binding affinity of sterol and capsicein was studied using molecular docking. The developed model predicted strong binding affinity for Tyr 47.

P-103

New *phytophthora* strain on cinnamon

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A recent survey conducted in Kodagu district of Karnataka observed the incidence of a foliar infection in *Cinnamomum zeylanicum* characterized by the appearance of reddish brown spreading necrotic areas on the margin of the leaf blade. The infected leaf tissue was disinfested for 2 min in 0.1% NaOCl and plated on PVPH selective medium and incubated for 72h at 24±1°C. Two different mycelial growth observed on the same tissue was sub-cultured separately and identified to the genus level as *Phytophthora.* The isolates (11-24 and 11-25) showed variation in sporangial morphology as well as colony morphology. The sporangia of the isolates were non-caducous, papillate, hyaline, measuring 38.88 to 77.76 × 19.44 to 34.02 µm (11-24) and 43.74 to 58.32 × 34.02 to 38.88 µm (11-25). The pedicel length ranged from 19.44 to 145.8 µm (11-24) and 19.44 to 68.04 µm (11-25). The sequence analysis of the ITS region and the information on morphological features confirmed the identity (99%) of one of the isolates (11-25) as *P. citrophthora.* But the sequence analysis of the ITS region of the other isolate showed only 83% similarity with *P. citrophthora*. A further study is warranted to confirm its identity and to ascertain whether it is a new species or not. As this collection was made from a mixed cropping system with cardamom and black pepper in the high ranges of Karnataka, efforts were also made to check their cross infectivity in these crops. The isolates varied in their infectivity and the isolate 11-25 was found to infect both black pepper and cardamom whereas the isolate 11-25 could infect only black pepper. The sequence data of these isolates were further compared with the world populations of *P. citrophthora* and *P. colocasia.* The results showed that these isolates fall into a separate cluster showing their uniqueness from other isolates.

P-104

Effect of weed management and nitrogen levels on growth and yield of coriander

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A field experiment on coriander (*Coriandrum sativum*) consisting of seven weed control treatments *viz*., T_1= weedy check, T_2= one hand weeding (HW) at 20 DAS, T_3=two HW at 20 and 40 DAS, T_4= pendimethalin @1.0 kg ha^{-1}, T_5= pendimethalin + HW at 40 DAS, T_6= oxadiargyl @ 0.06 kg ha^{-1} and T_7= oxadiargyl + HW at 40 DAS and four levels of nitrogen (0, 25,50 and 75 kg ha^{-1}) was undertaken. Coriander variety RCr 436 was sown at a row spacing of 30 cm. Pooled results of two years indicated that all the weed management treatments significantly improved the growth and yield attributing characters of coriander at most of the stages studied in comparison to weedy check. The maximum values of these parameters were recorded under two HW treatments that were at par with pre emergent pendimethalin at 1.0 kg ha^{-1}+ HW at 40 DAS. The highest mean seed (13.71 q ha^{-1}) and straw yields (25.83 q ha^{-1}) were also obtained with two hand weeding treatment. It enhanced the seed yield to the extent of 164.7 per cent over control. It also fetched the highest mean net returns of Rs 15841 ha^{-1} and B: C ratio (2.39) among all the treatments evaluated. Application of pre emergence pendimethalin at 1.0 kg ha^{-1}+ HW at 40 DAS was found the next superior and equally effective treatment in enhancing all these parameters. It recorded 11.7, 13.8, 38.4 and 162.7 per cent higher seed yield than one HW, pendimethalin, oxadiargyl + HW and weedy check treatments, respectively. It also enhanced the net returns by a magnitude of Rs. 44847 ha^{-1} over weedy check and observed the maximum value of harvest index. Results further indicated that every increase in level of N from 0 to 75 kg ha^{-1} significantly increased the growth and yield attributing characters, yield, net returns and B: C ratio over lower levels. N fertilization at 75 kg ha^{-1} produced 11.9, 32.7 and 84.3 per cent higher seed yield and fetched 16.0, 47.4 and 154.5 per cent more net returns than 50 and 25 kg and control, respectively. The highest B: C ratio (2.35) was also obtained at this level of N. However, harvest index remained unaffected.

Secondary agriculture

P-105

Processing of turmeric by different curing methods and its effect on quality

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Studies on curing of freshly harvested turmeric rhizomes (variety Prathiba) with an initial moisture content of 78.89 per cent were conducted during April 2010. The rhizomes were cured using the traditional water boiling process for 40, 60 and 90 min, by steam boiling using TNAU model turmeric boiler for 30, 45 and 60 min, dipped in boiling water for 10 min and sliced to 3mm thick slices. The rhizomes obtained from different curing methods were sun dried in cemented drying yard between 9 AM to 3 PM and the weight loss during drying was recorded periodically till the rhizomes obtained constant weight. The maximum ambient temperature recorded during the day was 38oC. The cured turmeric were analysed for its biochemical qualities. The results of the study indicated that slicing significantly reduced the drying time to 9 days. Turmeric cured by traditional water boiling for 40, 60, 90 min, took 11 days for complete drying. While turmeric rhizomes cured in steam boiler for 60 min took 12 days for drying whereas when cured for only 30 min the drying time increased to 24 days. Increase in curing time resulted in significant reduction in curcumin, starch, essential oil and oleoresin content. Maximum retention of curcumin (5.91%) and essential oil (3.6%) was obtained for rhizomes cured by water boiling method for 40 min. However, the steam boiler had several advantages over traditional water boiling in terms of fuel consumption and the quantity of rhizomes that could be cured per batch.

P-106

Studies on development of abrasive square mesh drum ginger peeler for mechanical peeling of ginger

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Since scraping of ginger is a laborious process, mechanical peeling of ginger in a diamond cut mesh drum ginger peeler was attempted. The developed diamond cut mesh drum ginger peeler consists of a peeler drum of size 550 x 470 mm, mounted on a shaft of length 1540 mm having an outer and inner diameter of 33 and 27 mm. The peeler rotates in mild steel water holding tank size of 820 mm long, 770 mm wide and 450 mm depth. At one end of the hollow shaft, a handle of length 250 mm was provided to rotate the drum manually. Peeling experiments were conducted till sufficient peeling of ginger was obtained for varying drum capacities (5, 6 and 7 kg), rotational speed (20, 25 and 30 rpm) and peeling duration (5, 10 and 15 min). The quality of peeled ginger was evaluated in terms of the peeling efficiency and the material loss. The results indicated that the peeling efficiency of a diamond cut mesh drum ginger peeler, varied from a minimum of 33.04 per cent for peeling at a drum load of 6 kg at 20 rpm for 5 min to a maximum of 60.71 per cent for peeling at a drum load of 6 kg at 30 rpm for 15 min. It was also observed that as the drum capacity increased from 5 to 7 kg, the peeling efficiency reduced for all drum speeds and peeling durations studied. But for a given drum load, as the drum speed and peeling time increased the peeling efficiency increased. Peeling in a mechanical peeler is associated with the meat loss of ginger and is expressed as the material loss. It was observed that the material loss varied from a minimum of 1.25 per cent for peeling at a drum load of 6 kg at 20 rpm for 5 min to a maximum of 4.85 per cent for peeling at drum load of 6 kg at 30 rpm for 15 min. It was also found that the material loss decreased with increase in drum load and increased with the increase in drum speed and peeling time. The optimum machine parameters were obtained at a drum load of 6 kg per batch, operated at a drum speed of 25 rpm for peeling duration of 15 min, to produce sufficiently peeled ginger. The peeling efficiency and material loss at the optimum conditions were determined as 57.63% and 4.72% respectively. The dry ginger obtained after mechanical peeling was found to have essential oil of 2%, oleoresin of 4.6%, moisture content of 9.82% and crude fibre content of 2.5%.

P-107

Rapid quantitation of aflatoxins in spices and spice products by UPLC with Kobra cell derivatization and fluorescence detection

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An attempt was made to develop a specific, robust method using Ultra Performance Liquid Chromatography (UPLC) with immunoaffinity column clean-up and post column derivatization for the low-ppb detection of aflatoxins in some spices. The aflatoxins were first extracted from homogenized

spices using 80:20 methanol/water and diluted 6:1 with phosphate buffered saline (PBS), pH 7.2 and cleaned up using immunoaffinity columns (AFLAPREP™), which binds the aflatoxins present in the sample. The bound toxins were then eluted out using methanol and injected into UPLC and separation were carried out on AQUITY BEH, C18 column (1.7µm, 100 mm×2.1 mm) using methanol: water (60:40) mobile phase at the flow rate 0.25ml/min. Toxins emerging out of the column were electrochemically derivatized using a Kobra Cell® for enhanced fluorescence, followed by detection using a fluorescence detector at 362nm excitation and 425nm emission wavelength. Calibration curves were constructed using all for reference standards (AFG2, AFG1, AFB2 and AFB1) with different concentrations. For recovery experiments spiking procedures were followed. The proposed method showed acceptable linearity, precision, selectivity, and recovery for reliable quantification at meaningful concentration limits.

P-108

Standardization of stem thickness and stem length for harvesting cinnamon bark in two genotypes

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An experiment was conducted to study the effect of stem thickness and stem length for harvesting cinnamon (*Cinnamomum verum* J. Pres.) bark under AICRP on Spices. Twelve treatment combinations *viz*., two genotypes; Konkan Tej (G1), ACC-11 (G2), two lengths of stem; 50 cm (L1), 100cm (L2) and three thicknesses of stem; 1-2cm (T1), 2-3cm (T2), 5-6cm (T3) were used for experimentation. There were no significant differences in bark thickness before and after drying, quill fresh and dry weight in the genotypes studied and length of cinnamon stem selected for bark extraction. Significantly highest bark thicknesses before (1.14mm) and after (0.82mm) drying and quill fresh (111.21g) and dry (56.64g) weights were recorded in T3 (5- 6 cm thick stem) treatment. Interaction effect of genotype, length and thickness of stem selected for coppicing indicate significant differences in bark thickness before and after drying and quill fresh and dry weight. Significantly maximum bark thickness before drying (1.74 mm) was recorded in treatment combination G2L1T3, which was at par with G1L2T3 (1.72 mm), G2L2T3 (1.71 mm) and G1L1T3 (1.67 mm). The treatment combination G1L2T3 produced significantly highest bark thickness after drying (1.33mm) quill fresh weight (223.31g) quill dry weight (117.28 g) respectively. Significantly low bark thickness before drying (1.00 mm) quill fresh weight (49.13 g) and quill dry weight (22.92g) were recorded in treatment combination G1L1T1, which were at par with treatment combination G2L1T1. Significantly low bark thickness after drying (0.65 mm) was recorded in treatment combination G1L2T1 which was at par with G2L2T1 treatment combination 0.70 mm. Oil percentage of different thicknesses of coppiced stem indicate higher values in more thick than less thick stem. Higher oil percentage was observed in 5- 6 cm thick stem i.e. Konkan Tej (3%) and ACC-11 (2.50%) respectively. Thus the coppicing for extraction of bark 5- 6 cm thick stem is used in Konkan Tej and ACC-11 genotypes of cinnamon.

P-109

Flavour profile of cardamom hybrids

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In the present study, twenty cardamom (*Elettaria cardamom* Maton.) genotypes were evaluated for essential oil content and flavor constituents. The essential oil was extracted by hydrodistillation and the constituents were determined by GC and GC-MS. The essential oil content ranged between 3.5-6.7%. The chief components of the essential oil, namely, 1, 8-cineole and α-terpinyl acetate ranged from 21.1-33.5% and 37.0-46.2% respectively. Among the genotypes tested, GG- self recorded the highest essential oil content (6.7%) with 45.8% α-terpinyl acetate and 26.2% 1, 8-cineole, which was followed by GG-OP with 6.0% essential oil content, 46.2% α-terpinyl acetate and 27.5% 1, 8-cineole. GG-OP recorded the highest α-terpinyl acetate (46.2%) followed by RR-1 x 893(46%); whereas the highest 1,8-cineole content (33.5%) was observed in RR-I self.

P-110

Essential oil and oleoresin profile of seven selected ginger varieties

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In the present study, seven selected varieties of ginger (*Zingiber officinale* Rose.) *viz*., Himagiri, Mahima, Rejatha, Rio-de-Geneiro, Suprabha, Surabhi and Varada, grown in IISR Research Farm at Appangala were evaluated for essential oil and oleoresin contents and their constituents. The constituents of essential oil were determined by, GC and GC-MS, and gingerols and shogaols by HPLC. The essential oil and oleoresin contents varied from 0.9-2.2% and 2.8-3.6% respectively, on dry weight basis. Major components of the essential oil were zingiberene (28.6-37.7%), β-sesquiphellandrene (13.9-15.9%), farnesene (5.5-19.9%) and ar-curcumene (7.9-9.9%). The predominant components of the oleoresin namely, 6-gingerol, 8-gingerol and 6-shogaol ranged from 1.1-1.4%, 0.1-0.3% and 0.2-0.3% respectively. The variety, Surabhi was superior with the highest essential oil (1.2%) and oleoresin (3.6%) contents, and total gingerols (1.7%) and shogaols (0.7%).

P-111

A modular UPLC system for routine analysis of Capsaicin from Indian Chilies

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The study was undertaken to develop simple and reliable UPLC method for simultaneous determination the three major ingredients, namely capsaicin, dihydrocapsaicin and norhydrocapsaicin in two varieties of chili. ACQUITY UPLC is a better technique than HPLC in terms of performance and speed, so it was selected. The good separation of these compounds was achieved on ACQUITY UPLC^{TM} BEH C_{18} (100×2.1mm, 3.5μ) with gradient elution using Acetonitrile and 1% Acetic acid in water (60:

40)as the mobile phase at a flow rate of 0.25ml/min. The precision was found to be within the limits. The linearity studies indicated the capsacinoids obeys Beer's law and revealed the specified range of linearity. The robustness was observed from the insignificant variation in the analysis by changes in flow rate, mobile phase ratio, wavelength, column oven temperature. Using this methodology analyzed results showed the presence of considerable variability in capsaicin content among the two varieties of chili.

P-112

A novel approach for the determination of phytochemicals in spices

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The aim of the present study was to develop a rapid, simple, sensitive, robust, and improved Ultra Performance Liquid Chromatography (UPLC) method for detection, separation and quantification of some phytochemicals in spices. The chromatographic separation was achieved in less than 6 min by UPLC (AQUITY UPLC BEH, C18 column, 1.7µm, 100 mm × 2.1 mm) using gradient elution of acetonitrile and water with a flow rate of 0.25 mL/min at λ 210 nm. Standard calibration curves were linear in the range of 0.0020 - 0.0300 mg/mL. Good results were achieved with respect to repeatability and recovery. The proposed method was validated in terms of selectivity, linearity, accuracy, precision, range, detection and quantitation limit, system suitability and solution stability. This method can be successfully employed for simultaneous quantitative analysis of phytochemicals in spices and spice products.

P-113

Studies on the shelf life enhancement of mint by modified atmospheric packaging

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A study was carried out to enhance the shelf life of mint leaves by modified atmospheric packaging system. The mint leaves were given pre treatments *viz*., pre chilling and pre cooling to reduce the heat. LDPE 152µ was used as packaging material which has less permeability to oxygen. Storage study was conducted for optimized parameters viz., pre cooling treatment, product to free volume ratio (1:8 for mint) and for gas composition (5% - O_2, 5% - CO_2 and 90% - N_2). Modified atmospheric packed mint leaves kept at room temperature had started decaying after 4th day. Modified atmospheric packed mint leaves can be stored up to 20 days without any spoilage at refrigerated condition. The cost of production of mint leaves 100g / package is Rs 4.00/-.

P-114

Influence of harvesting on the quality parameters of turmeric

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A field experiment was conducted to study the effect of different harvest periods *viz*., 6th, 7th month after planning and final harvest (between 220 and 245 days) on the quality parameters of turmeric (*Curcuma longa* L.) varieties. In general, high curcumin, essential oil and oleoresin content were found in all varieties when harvested at 6 month after planting and then eventually decreased at final harvest stage. The variety Narendra Haldi I recorded more curcumin content as high as 11.50% at 6 month after planting, 7.77% at 7 month after planting and 6.07% at final harvest (230days). The variety, Suranjana gave high oil yield of 8.08% at 6 months after planting and then decreased to 3.04% at harvest. At 6 months after planting, the variety IISR Alleppy Supreme gave the high oleoresin content (25%) which then decreased to 23% at 7 month after planting and then finally got reduced to 7.70% at final harvest (230days). Considering the importance of quality parameters in turmeric, harvesting at six months after planting would be beneficial compared to regular harvest at full maturity.

Socio economic issues

P-115

Spices production status and potential of Bagalkot district

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Bagalkot district with a prime role in the production of horticultural crops has undergone dramatic transformation in terms of irrigation facilities with the upcoming of Upper Krishna irrigation projects. The lateral expansion of irrigation and improved ground water level has been a boon in increasing area under spices in general and turmeric in particular. Turmeric crop is adopted by farmers on a large scale and has helped to increase their incomes. The area under turmeric is second highest in Karnataka state but the productivity is 6.31 t/ha. Turmeric was a choice since the problems of diseases and pests were not experienced initially. The crop is managed well by adequate nutrition and irrigation. Some farmers are growing it on raised beds with drip irrigation and have achieved astonishing increased yields. But of late foliar diseases are causing losses. Farmer's who have taken up prophylactic measures and following integrated cultural management practices with the technical support from KVK have been successful in minimizing loses. The increasing area under turmeric is posing a challenge. It calls for greater efforts to undertake location specific varietal evaluation to identify potential new genotypes, identifying better management practices of biotic stresses, establishing better marketing channels for farmers produce to realize higher returns, possibility of establishing processing units like oleoresin extraction, etc. The other spice crops grown are dry chillies, coriander, garlic and fenugreek on moderate to small scales. The scope to increasing area under dry chillies is restricted due to less rains in *kharif* though farmers grow chilli + onion in mixed/inter cropping manner like that practiced under transitional zone i.e. zone VIII. There is great potential to introduce ginger in assured irrigation belts and benefit farmers in areas where turmeric is cultivated.

P-116

Rapid and easy multiresidue method for determination of pesticide residues in spices using Gas Chromatography–Tandem Mass Spectrometry (GC–MS/MS)

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In this study a multiresidue method was developed for the determination of several pesticides (organochlorine, organophosphorus, pyrethroids, triazole, amidine) using gas chromatography– tandem mass spectrometry (GC–MS/MS). A version of the "quick, easy, cheap, effective, rugged, and safe" (QuEChERS) method was modified to use ethyl acetate (EtOAc) rather than acetonitrile (MeCN) for extraction of multiple pesticide residues in spices. EtOAc is better suited than MeCN for gas chromatographic (GC) analysis. A mixture of pesticides amenable to gas chromatography (GC) was quantitatively recovered from spiked Chilli and turmeric. The pesticides chosen for this study included many of the most frequently detected ones and/or those that are most often found to violate the maximum residue limit (MRL) in food samples, some compounds that have only recently been introduced, as well as a few other miscellaneous compounds. The spiking levels for the recovery experiments were 0.02 and 0.05 mg/kg. Adequate pesticide quantification and identity confirmation were attained, even at the lowest concentration levels, considering the high S/N ratios, the very good accuracies and precisions, as well as the good matches between the observed ion ratios. Mean recoveries mostly ranged between 70-110%, and relative standard deviations (RSD) were generally below 25%. Based on these results, the methodology has been proven to be highly efficient and robust and thus suitable for monitoring the MRL compliance of a wide range of commodity/pesticide combinations.

P-117

Constraints and mechanisation in turmeric cultivation in Northern Karnataka

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Turmeric is one of the cash crops of northern Karnataka being cultivated under irrigated condition mainly in Belgaum, Bagalkot, Bidar and Gulbarga districts. In these areas turmeric is cultivated in ridges and furrow method employing manual laboures in every stages of its cultivation. In the last few years the price of turmeric ranged between hardly Rs. 2500 to 4000 per quintals. There was high labour requirement in turmeric cultivation and its cultivation was non ruminative. Because of this area under turmeric has decreased. In the last two years the turmeric prices increased tremendously which ranged between Rs. 18000 to 21000 per quintals. In the turmeric growing areas there are acute shortage of labours. To overcome this farmers are adopting labour saving devices in turmeric cultivation. Different types of farm machinery or equipments have been designed for turmeric cultivation. These machineries are available in the turmeric growing areas on hire basis like power tillers, ridge farmer, turmeric harvester, cooking machines, drying machines, polishing machines, etc. The turmeric growers are adopting. There machines to reduce the labour requirement and to reduce the cost of cultivation. The farmers are very happy with the labour saving technology. Very good marketing facilities for turmeric are available in Sangli market and the farmers are selling their produce in this market and getting good price.

P-118

Intellectual property rights in spices and initiatives by IISR

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The PPV & FRA that came into force in 2001 has opened new vistas for the breeders and farmers alike for the development of new high yielding spice varieties adapted to local agro-climatic conditions. Indian Institute of Spices Research has been instrumental in framing the guidelines for DUS testing in spice crops *viz.*, ginger, turmeric, black pepper and small cardamom. It has taken up commercialisation of released varieties of turmeric and ginger through non-exclusive licensing from 2010 onwards. Patenting has its own relevance in spices, as can be seen from the storm raised by the turmeric case. This has probably led to the initiative of safeguarding the traditional knowledge of India, through the TDKL initiative, which is expected to prevent incidents of bio piracy. However in spite of the global relevance to patenting in spices the number of patents granted for spices and related processes is extremely low in India as compared to other countries. This may be due to the low awareness, the prohibitive cost involved in patent filing and its maintenance. IISR has made its first steps towards patenting through a novel technology for production of white pepper.The trademarks have made a good impact in spice trade and has been exploited comparatively well by different entities. The trademark of IISR registered under four classes is being used for commercialisation and marketing of its products. Geographical Indication provides unlimited time of protection to products from a particular locality or region. Malabar Pepper, Alleppey Green Cardamom and Coorg Green Cardamom are popular examples of GI registration in spices. There are a number of eligible GIs in spices, which need to be identified and popularised for economic benefits of farmers and tribal communities. IISR has provided logistic and scientific support to Spices Board for securing GI in Malabar pepper and Indian Cardamom. With the opening up of the Indian trade through globalization, it is imperative to be aware of all the avenues available for the protection of our technologies, so as not to be left behind in competition, and creating awareness about the issues of IPR in spices is paramount to that objective.