Souvenir & Abstracts

SYMPOSIUM ON
SPICES, MEDICINAL AND AROMATIC CROPS

SYMSAC-IX

Spices for doubling farmer's income

15 – 17 March, 2018

School of Agricultural Sciences &
Rural Development, Nagaland University
Medziphema, Nagaland

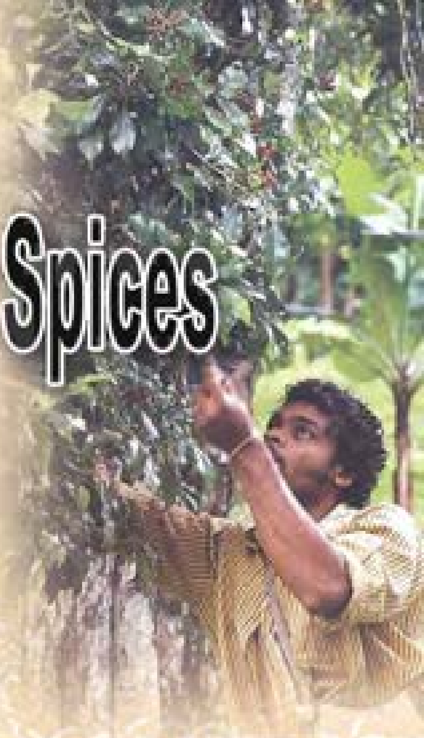
Organizers
School of Agricultural Sciences &
Rural Development, Nagaland University, Nagaland

Indian Society for Spices, Kozhikode, Kerala

Co-Organizers
Department of Horticulture, Govt. of Nagaland
Department of Agriculture, Govt. of Nagaland

In Collaboration with

ICAR, New Delhi
ICAR-IISR, Kozhikode, Kerala
DASD, Kozhikode, Kerala
NEC, Shillong, Meghalaya
NERAMAC, Guwahati, Assam
HSNEI, Medziphema, Nagaland



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

Spices for Doubling Farmer's Income

15-17 March 2018
School of Agricultural Sciences & Rural Development
Nagaland University, Medziphema Campus, Nagaland

SOUVENIR & ABSTRACTS

Organized by

School of Agricultural Sciences & Rural Development
Nagaland University

Indian Society for Spices
Kozhikode, Kerala

In collaboration with

Indian Council of Agricultural Research, New Delhi

ICAR-Indian Institute of Spices Research, Kozhikode, Kerala

Directorate of Arecanut & Spices Development, Kozhikode, Kerala

North Eastern Council, Shillong, Meghalaya

North Eastern Regional Agricultural Marketing Corporation Limited, Guwahati, Assam

Horticultural Society of North East India, Medziphema, Nagaland

National Symposium on Spices and Aromatic Crops (SYMSAC IX)
Spices for Doubling Farmer's Income
15-17 March 2018, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema Campus, Nagaland

Organized by

Indian Society for Spices, Kozhikode, Kerala
School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema Campus, Nagaland

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March 2018

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“Alone we can do so little
Together we can do so much”

Our deepest sense of gratitude to

- ISS & IISR-ICAR for identifying SASRD, Nagaland University as befitting to host this event
- SASRD, Medziphema Campus, NU, for extending full cooperation and support system thus paving the way for smoothly organizing the event of this magnitude
- All committee conveners, co-conveners and members of different sub-committee, for their tiredless effort throughout the process of organizing the event
- Department of Horticulture, GoN & Department of Agriculture, GoN, for always extending full cooperation and support in organizing such big events
- ICAR, IISR, DASD, NEC, NERAMAC, RD (GoN), NEIDA (TATA Trusts) for their willingness to collaborate with us in organizing this mega event
- All sponsors (Dept of Agriculture, GoN, Dept of Horticulture, GoN, NEC, NHB, DASD, NU, LRD, NERAMAC, IISR, CIH, NABARD, Spice Board) for genuinely contributing towards organizing SYMSAC-IX
- Media partner (Nagaland Post) for the wide coverage of the event
- All volunteers who had willingly and sincerely carried out their assignment
- All oral and poster paper presenters for contributing their expertise making the event meaningful and worthwhile
- All participants in business meet, spice growers, exhibitors for making this event successful through their valuable presence
- All the buyers, exhibitors, spice growers for their enthusiasm and being a part of this long felt needed event
- All those who worked behind the scene in making this dream event a reality

Prof. Akali Sema
Convener
SYMSAC-IX

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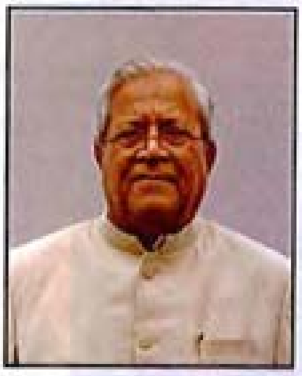
P.B. ACHARYA
Governor of Nagaland

सत्यमेव जयते

RAJ BHAVAN
Kohima - 797001

March 09, 2018



MESSAGE

I am happy to learn that School of Agricultural Sciences and Rural Development, Nagaland University; Indian Society for Spices, Kozhikode, Kerala; Department of Horticulture, Government of Nagaland and Department of Agriculture, Government of Nagaland are organizing the Ninth National Symposium on Spices and Aromatic Crops during 15th -17th of March 2018 at SASRD, Nagaland University, Medziphema.

I hope the seminar will provide opportunity to bring all stakeholders together and share the technological advancement in order to improve the spice scenario in the north east region.

I wish the organizers and participants a good deliberation and have a successful symposium.

9/3/18

(P. B. ACHARYA)

Tel : +91-370-2242881 (O) +91-370-2242898 (Fax) Email : rajbhavankohima@nic.in

सत्यमेव जयते

त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

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भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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MESSAGE

I am happy to learn that School of Agricultural Sciences and Rural Development, Nagaland University in collaboration with Indian Society for Spices, Kozhikode, Kerala is organizing the Ninth National Symposium on Spices and Aromatic Crops with the theme *"Spices for Doubling Farmer's Income"* (SYMSAC-IX) from 15-17 March, 2018 at Nagaland University, SASRD, Medziphema, Nagaland.

Spices and aromatic crops form the core sector of overall horticulture scenario in India. Being a leading country in spices and condiments production and consumption India has a vast opportunity to increase the volume of production of these crops as well as increasing farm profitability in order to increase the farmers income. Use of newer technologies to increase farm productivity and greater emphasis on crop specific disease management research would be of paramount importance in these sensitive crops. The prime Minister of India has expressed that 'it is the need of the hour to control the declining trend of farm income and achieve the target of doubling farmer's income in next the five years'. I hope that SYMSAC-IX has immense opportunity for discussing the various facets of Spices and Aromatic Crops' production as well as developing strategies for Doubling Farmer's income.

I congratulate the organizers and stakeholders for timely organization of the National Symposium on a very important issue and convey my best wishes for its grand success.

(T. MOHATATRA)

Dated the 12th March, 2018
New Delhi

नागालैण्ड विश्वविद्यालय
NAGALAND UNIVERSITY
(A Central University)

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Prof. Pardeshi Lal
Vice-Chancellor

Dated: Lumami, 12th March 2018

MESSAGE

It gives me immense pleasure to know that the organizers of the National Symposium on "Spices for doubling farmer's income" are bringing out a souvenir.

Being one of the major producers and exporters of spices in the world, there is a need for India to look into the issues of sustainability and keeping pace with technological advances.

Better planning, more research and seamless networking between the producers, researchers, marketing personals and other stakeholders will go a long way in the proper development of spices.

Therefore, this National Symposium is a great opportunity to have researchers, producers, marketing personals, development agencies, progressive farmers and other stakeholders under one roof for sharing findings, ideas, and shortcomings on key issues. Such an exercise is necessary in the formulation of effective strategies towards not only doubling the farmer's income but also contributing to the national economy.

I fully appreciate the programme being organized and express my best wishes to the organizers.

Pardeshi Lal

(PARDESHI LAL)
Vice-Chancellor

डा. आनन्द कुमार सिंह
उपमहानिदेशक (बागवानी विज्ञान)

Dr. Anand Kumar Singh
Deputy Director General (Hort. Sci.)

भारतीय कृषि अनुसंधान परिषद
कृषि अनुसंधान भवन–II,
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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN-II,
PUSA, NEW DELHI-110 012 (INDIA)

MESSAGE

Various developmental strategies in horticultural sector vis-à-vis 'Spices and Aromatic Crops' have mainly focused on increasing the production in the past years. As a result, India has witnessed manifold increase in overall production of Spices and Aromatic Crops and thereby the socio economic status of the farmers involved in this sector has also witnessed improvement.

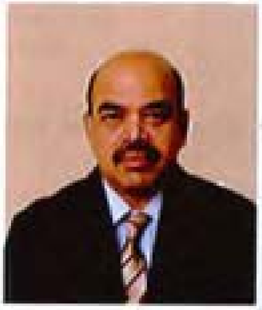
It is a matter of great pleasure to know that School of Agricultural Sciences and Rural development , Nagaland University and Indian Society for Spices, Kozhikode, Kerala is jointly organizing the Ninth National Symposium on Spices and Aromatic Crops with the theme *"Spices for Doubling Farmer's Income"* (SYMSAC-IX) from 15 to 17 March, 2018 at the School of Agricultural Sciences and Rural Development, Nagaland University, Nagaland.

The prevailing situation demands the shift in strategic focus from merely increasing the volume of production to increasing farm profitability as well as farmers income.

I convey my best wishes for the grand success of the National Symposium.

(Anand Kumar Singh)

S.K. PATTANAYAK
SECRETARY



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कृषि, सहकारिता एवं किसान कल्याण विभाग
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture, Cooperation & Farmers Welfare

MESSAGE

I am delighted to learn that the ninth edition of the Symposium on Spices and Aromatic Crops (SYMSAC) is to be organized with a theme of "Spices for doubling farmers' income" at Nagaland University from 15-17 March 2018.

Production of spice crops is gaining momentum in the country and India has been playing a very important role in the spice market of the world since time immemorial. In ancient times nearly all of the global requirement of the spices were produced in India and exported. This attracted people across the borders to come to India for Spice trade. Vast scope exist for cultivation of expensive spice crops like Saffron, Cardamom, Turmeric, Chillies, Ginger and Vanilla beans which will benefit the farmers in doubling their income. The organic farming practice of growing such crops in India is increasing rapidly, especially in north eastern parts of the country.

Mission for Integrated Development of Horticulture (MIDH) of Government of India has had tremendous impact on improving production and productivity of spices in the country including North-Eastern States. The Lakadong variety of turmeric with high curcumin, the ginger variety of North-East with low fiber content, the Naga King Chillies / Mizo Chillies with high pungency and the luxuriously growing black pepper are spices of tremendous potential in improving the income level of the farmers in North-East and economy at large. Application of right production technologies, proper processing, transportation and marketing could transform the economic scenario of the region.

Spices sector is one of the most vibrant sectors of the Indian agricultural trade. With stiff competition arising from several existing players and new entrants at the International level, retaining the traditional competitive advantage in this sector is a challenge confronting the spices industry. I hope SYMSAC-IX would enable the stakeholders to come out with an action plan for the development of the spice crops for the betterment of the people of North-East through improved income generation.

I wish the Symposium a grand success.

(S.K. Pattanayak)

New Delhi
12th March, 2018

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राम मुईवा, आई. ए. एस.
सचिव
उत्तर पूर्वी परिषद
उत्तर पूर्वी क्षेत्र विकास मंत्रालय
भारत सरकार

RAM MUIVAH, I.A.S
SECRETARY
NORTH EASTERN COUNCIL
MINISTRY OF DEVELOPMENT
OF NORTH EASTERN REGION
GOVERNMENT OF INDIA

Dated, the 8th March, 2018

MESSAGE

I am delighted to know that the School of Agricultural Sciences & Rural Development, Nagaland University and Indian Society of Spices, Calicut is organizing the **National Symposium (SYMSAC-IX) on "Spices for doubling farmers' income"** at Nagaland University, Medziphema campus, Dimapur in partnership with Department of Horticulture and the Department of Agriculture, Govt. of Nagaland.

I am sure this National Symposium being organized during 15th – 17th March, 2018 and B_2B meet for farmer's interactive session will provide an opportunity to all stakeholders including farmers and entrepreneurs to create awareness about the spice cultivation activity as a viable and profitable alternative, with a potential to generate remunerative self-employment among small & marginal farmers & earn the much needed foreign exchange in the State of Nagaland in particular.

I wish the event a grand success.

(Ram Muivah)
Secretary, NEC

Nongrim Hills, Shillong - 793003, Tel. : (0364) 2522644, 2522645 (O), 2521560 (R), Fax : (0364) 2522643, e-mail : sect-nec-meg@nic.in

T. IMKONGLEMBA AO,IAS
Agri Production Commissioner &
Commissioner & Secretary Agriculture
Govt. of Nagaland, Kohima

D.O. No...................... *Date.10:.05:.2018*

MESSAGE

The agro climatic zone of Nagaland has a vast potential for production of spices like cardamom, ginger, turmeric etc. The production of spices in the State can be increased by various scientific intervention leading to doubling of farmers income in the region.

Though, various government programmes are being implemented in the State to increase the area production of the crops, there is need to rethink in a stratagic planning so that the knowledge of the right type and variety of the crops can be transmitted to the farmers of the State.

Therefore, I congratulate the organizing committee to organise such a National Symposium on Spices and Aromatic Crops in the state is in the right direction not only for the scientific committee and extension workers but also to the resource poor farmers of the State.

I wish organising committee and National Seminar a grand success.

(T.IMKONGLEMBA AO)

NAGALAND UNIVERSITY

(A Central University Established by an Act of Parliament No. 35 of 1989)

School of Agricultural Sciences & Rural Development

Medziphema Campus – 797106 (Nagaland)

Prof. T. Lanusosang

Pro-Vice Chancellor

Date: 12th March 2018

MESSAGE

I am glad to know that the organisers of the 9th National Symposium on Spices and Aromatic Crops (SYMSAC-IX) are bringing out a Souvenir to mark the occasion. I congratulate the Department of Horticulture, SASRD and the Indian Society for Spices, Kozhikode, Kerala for jointly organizing the Symposium.

The School of Agricultural Sciences & Rural Development (SASRD), Nagaland University, has been playing a pivotal role in providing education and research in agricultural and allied disciplines to students and scholars across the country. My colleagues and I are pleased that SASRD has been chosen as the venue for the Symposium. I am confident that SYMSAC-IX would provide a platform for prolific interaction among researchers, farmers, traders and manufacturers and formulating strategies for spice cultivation, qualitative and quantitative improvement in crop production and market linkages aimed at doubling the farmers' income. Nagaland has the potential to become one of the leading states in producing spices, medicinal and aromatic crops. As such, the deliberations and recommendations of SYMSAC-IX can further increase the scale of spice cultivation, generate farmers' income and boost the state's economy.

I wish the SYMSAC-IX a huge success.

(T. LANUSOSANG)

PLENARY LECTURES

North East - Spice hub of India

V A Parthasarathy

ICAR Adjunct Faculty in Horticulture (TNAU & IARI)
Formerly Director, ICAR-IISR, Kozhikode, Kerala
E-mail: vapartha@gmail.com

If Europeans did not develop the taste for spices, the history of India would have been different. North East has been the source of many hitherto unknown spices such as Lisi (*Illicium graffiti)* of Arunachal Pradesh. The ginger wealth of North East has been reasonably exploited. History of spices is history of the nation. Spices play more important role in the food industry world over. The estimated growth rate for spices demand in the world is around 3.19%., which is just above the population growth rate. India has been a traditional producer, consumer and exporter of spices. There are about 109 spices listed by International Organization for Standardization and India grows about 60 of these spices. Almost all states in the country produce one or other spices. Spices exports have registered substantial growth during the last five years, registering an annual average growth rate of 21% in value and 10% in volume and India commands a formidable position in the world spice trade. During 2012-13, a total of 6,99,170 tonnes of spices and spice products valued Rs.11171.16 crores (US$2040.18 million) has been exported from the country as against 5,75,270 tonnes valued Rs.9783.42 crores (US$ 2037.76 million) in 2011-12, registering an increase of 22% in volume and 14% in rupee terms of value.

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

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

The six agro-climatic zones are:

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

Characteristics of the North East region and Himalayan states

- Hilly terrain and poor connectivity and accessibility.
- Extremely fragile ecosystem with huge biodiversity.
- Shifting cultivation (Jhum).

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

Peep into history of spices!

In ancient times, spices were as precious as gold and as significant as medicines, preservatives and perfumes. Spices have been used since time immemorial to enhance or vary the flavours of foods. One of the first uses of spices was for religious purposes such as for incense, embalming, in sacrificial rites and as charms, perfumes or medicines. In the middle Ages, spice became a luxury item, a commodity so valued that it was accepted as currency. And is it too outlandish to claim that America was discovered due to spice-after all, it was the search for trade routes to India's valuable spices that inspired explorers like Columbus (Brown 2003 not mentioned). The resultant spice trade is an integral part of the history of the rising and falling empires of India, China, Italian city states like Venice, Holland, England and Portugal. From ancient times to the present, Asia has been well known as the 'Land of Spices'. The Maluku Islands of Indonesia, also known to English speakers as the Moluccas, are referred to as the 'Spice Islands'. For the Indians who produce and export the majority of spices for world markets, the term 'Spice Bowl of the World', is applied to the State of Kerala. Many of the world's finest spices like black pepper, cardamom, nutmeg, ginger and turmeric have been produced in Kerala.

The fame of Indian spices is older than the recorded history. The story of Indian spices is more than 7000 years old. Centuries before Greece and Rome had been discovered, sailing ships were carrying Indian spices, perfumes and textiles to Mesopotamia, Arabia and Egypt. It was the lure of these that brought many seafarers to the shores of India. Theophrastus described black pepper and long pepper (*P. longum* L.) in the 4th century BCE. The powerful Chola kings before 100 BCE supposedly took pepper to Indonesia (Parthasarthy *et al*. 2007 not mentioned). Long before Christian era, the Greek merchants thronged the markets of South India, buying many expensive items amongst which spices were one. Epicurean Rome was spending a fortune on Indian spices, silks, brocades, Dhaka Muslin and cloth of gold, *etc.* It is believed that the Parthian wars were being fought by Rome largely to keep open the trade route to India.

Spice trade

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

Area, production and productivity

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

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

The total import of spices in India during 2008-09 is about 83545 tonnes valued Rs. 765.4 crores. The import value has increased by 19% as compared to previous years. The major spices imported are black pepper, poppy seed, clove, cardamom, ginger fresh and cassia. Out of the total import of black pepper (10750 tonnes) more than 60% is light (immature) for oleoresin industry, extraction and re-export. Ginger fresh is imported mainly from Nepal (30% of import volume) is for domestic consumption. Poppy seed, cassia, clove and star anise are also imported to meet the domestic consumption as the production of these spices are less in India.

Spices in North East India - Tiger woken up

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

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

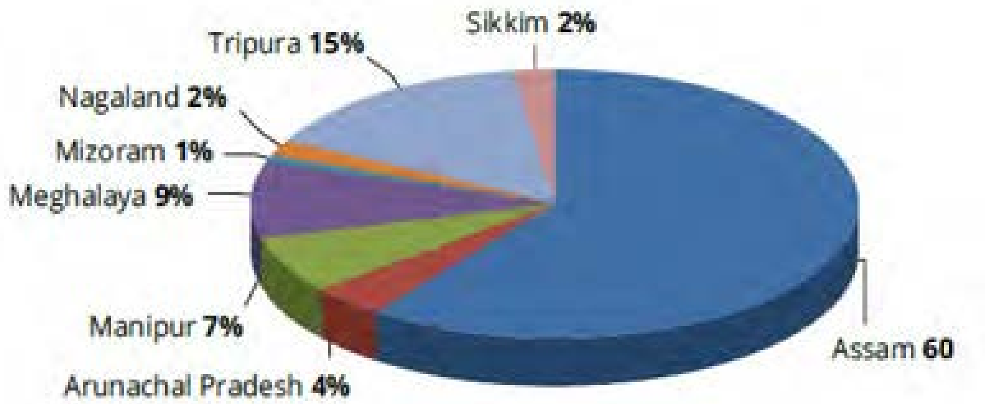
The entire NE Regions is horticultural biased in its agriculture. This is amply shown in the table 1 and figure 1.

Table 1. Horticulture area in North East

States	P.C. area under Horticulture
Arunachal Pradesh	31.70
Assam	14.04
Manipur	43.48
Meghalaya	30.09
Mizoram	60.57
Nagaland	7.70
Sikkim	45.76
Tripura	30.03
Total	18.91

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

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



***Source:** ISAP Analysis & NHB Data, 2011*

Fig. 1. Horticulture production in NE

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

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

Source: TMNE/DASD

If we have to achieve the target for the country in spice production (table 3), we have to look up to NE region only. While it is difficult to increase area under different crops, there is ample opportunity to increase the area under vertical and mixed farming conditions. Black pepper is an example. There must be a mission mode approach for black pepper. There are about 5 lakh hectares under tea and each hectare has about 125 shade trees which could be used to train black pepper. If all the tea gardens are convinced about this, we would be able to produce over 50000 tonnes of black pepper which would be around 75% of our total production. The productivity of black pepper is high in NE region.

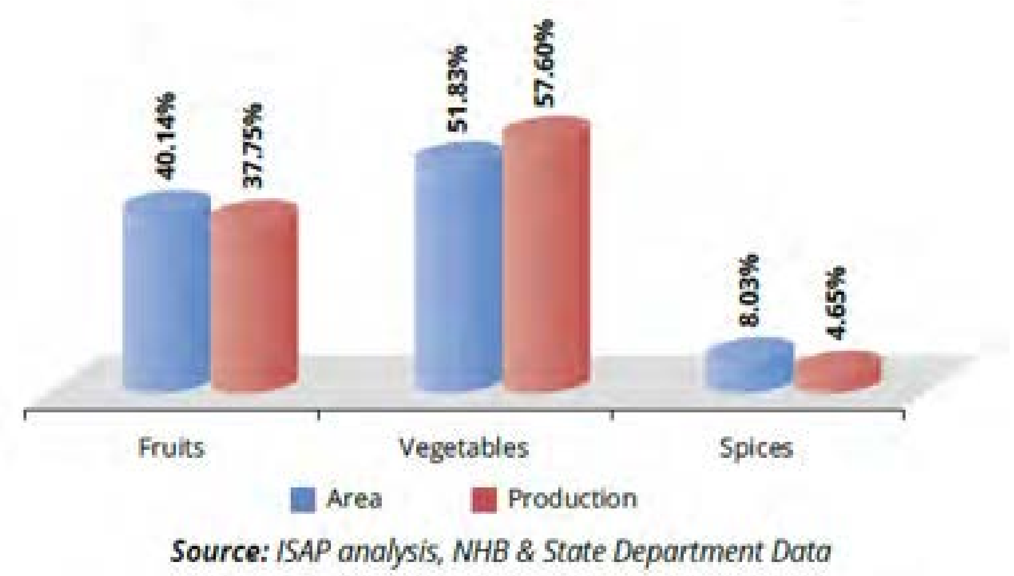


Fig. 2. Share in area and production of horticultural crops in NE region

Table 3. Estimated production target for spices in India (Qty. = tonnes)

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

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

Looking at spices differently!

Do spices only flavour the curries? They have better roles than what one imagines (table 4). It is also said that Indian spices and her famed products were the main lure for crusades and expeditions to the East. However, compared to other goods traded, spices took up less cargo space, so their popularity was higher than bulkier products. Ancient peoples such as the Egyptian, the Arab and the Roman made extensive uses of spices, not only to add flavour to foods and beverages, but as medicines, disinfectants, incenses, stimulants and even as aphrodisiac agents. No wonder they were sought after in the same manner gold and precious metals. Spices like turmeric and paprika, are used more for imparting an attractive colour than for enhancing taste. Most of the spices also finds place in various medicines. The extracts are used as infusions, decoctions, macerations, tinctures, fluid extracts, teas, juices, syrups, poultices, compresses, oils, ointments and powders.

Table 4. Uses of spices

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

Inherent qualities of Indian spices

Spices have been used for their flavour, aroma and colour and as preservatives for thousands of years. Their use in traditional systems of medicine dates back to centuries. Today there is greater scientifically validated knowledge on spices phytochemistry, therapeutic effects of their bioactive principles and mechanism of action. Most of the medicinal properties are attributed to the secondary metabolites – the essential oils and oleoresins, present in spices, a large number of which have been identified (table 5). The various phytochemicals include flavonoids, terpenoids, lignans, sulfides, polyphenolics, carotenoids, coumarins, saponins, plant sterols, curcumins, phthalides *etc.* Several chemical constituents in spices *viz*, most of the secondary metabolites, pungent principles, volatile oil compounds, alkaloids *etc*. are responsible for the numerous medicinal properties.

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

Table 5. Flavour compounds of spices

Spice	Important flavor compounds
Allspice	Eugenol, β-caryophyllene
Anise	(E)-anethole, methyl chavicol
Black pepper	Piperine, S-3-Carene, β-caryophyllene
Cardamom	α-terpinyl acetate, 1-8-cineole, linalool
Turmeric	Turmerone, zingeberene, 1,8-cineole
Ginger	Gingerol, shogaol, neral, geranial
Mace	α -pinene, sabinene, 1-terpenin-4-ol
Nutmeg	Sabinine, α -pinene, myristicin
Cumin	Cuminaldehyde, p-l,3-mentha-dienal
Fennel	(E)-anethole, fenchone
Saffron	Safranol
Vanilla	Vanillin, p-OH-benzyl-methyl ether

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

GI tag for NE spices

I. Naga chilli: In 2007, Guinness World Records certified that the ghost pepper was the world's hottest chilli pepper, 401.5 times hotter than Tabasco sauce; the ghost chili is rated at more than 1 million Scoville heat units (SHUs). Classic Tabasco sauce ranges from 2,500 to 5,000
II. Mizo chilli: Mizoram Birds Eye upto SHU 250,000. This chilli comes from eastern most part of India, bordering Burma. Just like it's sister chilli, Bhut Jolokia from this region, this one packs punch of heat in it. While it's not as hot as Bhut Jolokia, nevertheless it's still very hot at more than 2,00,000 SHU. The flavour and heat is wonderful and very enjoyable too. This chilli will make the perfect Vindaloo.
III. Karbi Anglong ginger: Ginger fields in Karbi Anglong. The district produces the best organic ginger in the world. The average annual production of ginger in the district is 30,000 tonnes and it is grown by about 10,000 farmers. The ginger grown in Karbi Anglong has a low fibre content. Varieties such as Nadia and Aizol (possibly Thingpui or Thinglaidon), which yield high quantities of dry rhizome and oleoresin oil, are in great demand among domestic buyers and exporters
IV. Lakadong turmeric: A very high curcumin variety native to the village Lakadong in Jaintia Hills of Meghalaya.

Road map for North East

The main strength of NE region is the genetic diversity – Collect, conserve and commercialize should be the motto.

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

The major developmental programmes envisaged under MIDH are:

- Production and distribution of planting materials through development of model nurseries, tissue culture and seed infrastructure.
- Rejuvenation/replanting programmes.
- Promoting INM/IPM strategies through development of forecasting techniques, plant health clinics, biocontrol labs *etc.*
- Technology dissemination through FLDs.
- Popularizing post harvest management technologies.

Conclusion and future thrust

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

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

Spices for doubling farmer's income

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Why double farmer's income?

Agricultural strategy in the country during the planned development era has been to ensure food security and farmers have responded to the nation's needs well and adopted Green Revolution technology. While, the country achieved commendable position in food production, enhancing incomes of the farmers and ensuring their income security, thus, has been of concern to all. National Commission on Farmers has addressed the issue of distress and farmers' welfare through a series of recommendations. Subsequently, the announcement was formalised in the Union Budget 2016-17 stating that an important objective of the Government is to double the income of farmers by the year 2022.

The Indian spices economy

India as a traditional producer, consumer and exporter of spices in the world holds a major stake in the global spices market with an estimated production of 8202 thousand tons of spices during 2016-17 from 3705 thousand ha (fig. 1). Though every state in the country grows at least a few spice crops, Kerala, Andhra Pradesh, Gujarat, Maharashtra, West Bengal, Karnataka, Tamil Nadu, Orissa, Madhya Pradesh, Rajasthan and North Eastern states are the major spices producing states. The increase in spices production from 2015-16 to 2016-17 was the highest (17.4%) among horticulture crops production. In a total of 43 principal agricultural commodities exported from India, spices stand 4th after marine products, buffalo meat and basmati rice. Indian spices are exported to more than 100 countries, however main importers are U.S.A, China, South East Asian countries, U.A.E, U.K, Germany, Saudi Arabia, Thailand, Netherlands, Sri Lanka, Mexico, Bangladesh, Brazil, Pakistan, Japan, France, Egypt (A.R.E), Spain, South Africa and Australia.

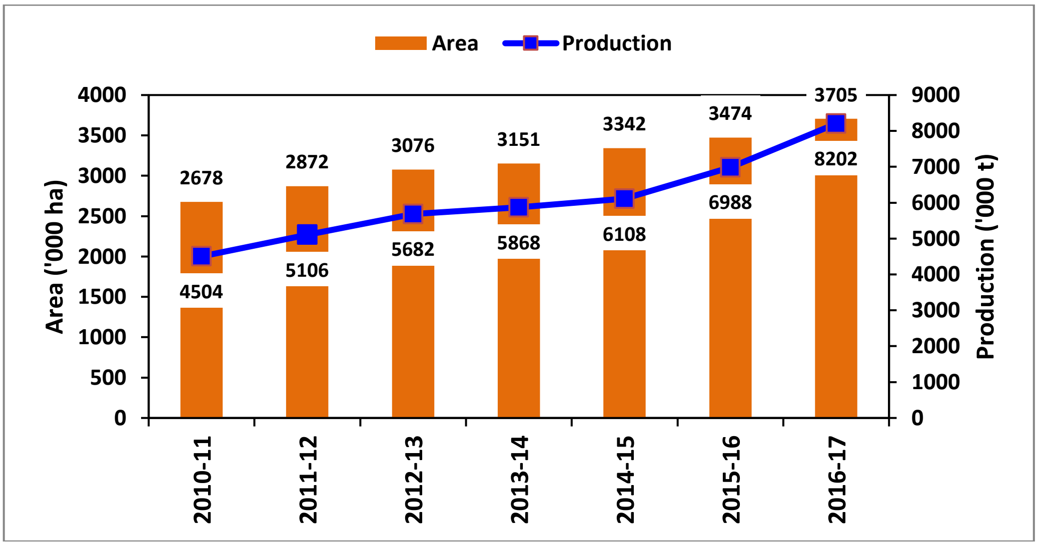

Fig. 1. Trends in spices area and production

In terms of export, a total of 10.07 lakh tons of spices and spice products valued at Rs. 19367.00 crores have been exported from the country during 2016-17 contributing 8.70% to the total agricultural products export. It is noteworthy to mention that only around 10% of our spices production is exported and it commands 43% share in volume and 48% in value of the world spice trade. The remaining spices are consumed in India which is an indication of the prevalence of the huge domestic market within the country. Among the export of different spices, maximum share was from chilli followed by seed spices, turmeric and black pepper. However in terms of value, mint products and spice oils and oleoresins contributed a major share of the total export earnings.

The food and pharmaceutical industry rely on these high value low volume commodities to produce an assortment of products that are designed to meet the varied needs of the consumers across the world. The estimated growth rate for spices demand in the world is around 3.19%, which is a shade above the population growth rate.

The major challenges in the spice production

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

In view of these challenges, there is a need to develop cutting edge technologies that are simple, cost-effective and farmer-friendly. Apparently, the spice sector has to inadvertently deal with many other risky situations, where the possibilities for adverse consequences that can cause marked disruptions are very high. There is great scope to improve the productivity of major spices by adopting technologies that will help to bridge the gap between potential yields realized in the research stations/progressive farmers' plots. ICAR-Indian Institute of Spices Research (IISR) and All India Coordinated Research Project on Spices (AICRPS) are working together on mandated spice crops production and productivity enhancement and its utilization through research advancements in developing new varieties, plant health management technologies and value addition.

Strategies for enhancing production through yield increase in spices

Increase in yield or productivity of spices and other enterprises is the single most important factor that can increase income. Since the area cannot expand much either through increase in net sown area or through increase in cropping intensity, enhancing the productivity is the only route available to enhance production. While varietal improvement through conventional breeding or biotechnology is a long term option, bridging yield gaps through adoption recommended agronomic practices, planning profitable crop mix that can maximise aggregate income and reducing crop losses through integrated pest management are short/medium term options that can bring additional income.

Improved varieties of spices

ICAR-IISR has released several high yielding and improved varieties of ginger, turmeric, cardamom, black pepper and nutmeg which have become very popular across the country.

High piperine and oleoresin containing varieties of black pepper (IISR Girimunda and IISR Malabar excel) which are also suitable for cultivation in high altitudes and plains has been released by ICAR-IISR. IISR Thevam and IISR Shakthi are tolerant to *Phytophthora* foot rot disease. High yielding varieties Sreekara, Subhakara, Panchami and rot knot nematode tolerant variety Pournami are suitable for all pepper growing locations of India.

Ginger varieties, IISR Varada and IISR Rejatha with high essential oil and oleoresin content are suitable for growing all over India. Apart from high oil content, IISR Mahima is also resistant to nematodes (*M. incognita and M. javanica*).

High yielding (Suguna, Suvarna, Sudharsana) and stable high curcumin yielding varieties suitable for growing throughout India have been developed by ICAR-IISR (IISR Prabha, IISR Pragati, IISR Kedaram, IISR Prathibha and IISR Alleppey Supreme).

Cardamom variety (IISR-Appangala-1) is preferred widely by the oil extraction industries, where as IISR-Appangala-2 and IISR Vijetha are suitable for mosaic affected areas of Karnataka. Cardamom variety IISR Avinash is a rhizome rot tolerant variety. High yielding and high quality varieties of nutmeg (IISR Viswashree and IISR Keralashree) have also been developed. IISR Keralashree is the first farmer's variety developed under farmer's participatory breeding programme. Cinnamon varieties (IISR Nithyashree and IISR Navashree) have high shoot regeneration capacity with high bark oil and oleoresin content.

It is often difficult to meet the ever increasing demand for planting material of these popular varieties. Hence, we have initiated granting of non-exclusive licenses from 2011 for commercial production of these varieties. Healthy disease free planting materials are provided to the licensees and they are entrusted with the responsibility of supplying quality planting materials without deteriorating the genetic purity. The institute is now linking their clients to these licensees who in turn meet the demand. ICAR-IISR has issued 25 plant variety licenses to the clients till date.

Quality planting material production

The major diseases in ginger and turmeric are soft rot caused by *Pythium* sp. and bacterial wilt caused by *Ralstonia solanacearum*. These pathogens are both seed and soil borne. Infection by these pathogens can be reduced by at least 50% through the use of disease free planting materials. A transplanting technique in ginger by using single bud sprouts (about 5 g) has been standardized to produce good quality planting material with reduced cost. The yield level of ginger transplants is on-par with conventional planting system. The technique involves raising transplants from single sprout seed rhizomes in the pro-tray and planting in the field after 30-40 days. The advantages of this technology are production of healthy planting materials and reduction in seed rhizome quantity and eventually reduced cost on seeds. The advantages of this method include less planting material requirement, 500-750 kg ha^{-1}, hence saving in seed cost and only 1/3rd of seed material is needed.

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

Vertical column method for quality black pepper

The continuous demand for quality planting material created a novel idea of producing orthotrope on vertical 2 m column having one foot diameter made with plastic coated welded wire mesh (size 4 cm) filled with composted pasteurized coirpith compost and vermicompost @3:1 ratio fortified with bio-control agent *Trichoderma harzianum* in poly house. Eight to ten cuttings are allowed to trail on the column and it would take four months to reach the top and produce more than 20 nodes. Each vine invariably produces lateral reproductive branches within three months time at 12th–15th node. The top 5-7 nodes have lateral branches also. The top 5 nodes can be used as orthotropic shoots as is done in Malaysia and Indonesia to induce fruiting laterals from the base. In four to five months time, on an average 150 single nodes (15 cuttings per vine × 10 vines around the vertical column) per column, one or two laterals and 10 top shoots can be harvested. The advantage of vertical column method is one can get three type of cuttings *viz*., normal single node cutting, laterals and top shoots.

Soil health management technologies

Green technologies for spices cultivation

Nutrient management plans for spices have been standardized for organic farming systems and organic packages have been developed for black pepper, ginger and turmeric integrating composts, oil cakes, biofertilizers/ PGPRs and biocontrol agents. In addition, an entomopathogenic fungus, *Lecanicillium psalliotae,* effective in controlling the cardamom thrips was potentially identified and evaluated at different agro-climatic conditions in Kerala and Karnataka. The technology is ideal for adoption in organic horticulture. Two new species of entomopathogenic nematodes *viz*., *Oscheius gingeri* sp. n. and *Steinernema ramanai* sp. n. are identified as potent biocontrol agents against shoot borer *Conogethes punctiferalis* infesting ginger and turmeric. A new species of group I tetrahedral shaped multiple nucleopolyhedrovirus (NPV) belonging to the genus *Alphabaculovirus* of family *Baculoviridae*, infecting *Spilarctia obliqua*, a polyphagous pest of ginger, turmeric and other crops was also identified as potential bio-agent.

Cropping system

Spice crops offer great scope for designing cropping system for doubling the farmers income. Black pepper being a climbing vine, is well adapted to grow as a under crop / mixed crop / intercrop with plantation crops. Humid rainforest ecosystem in the tropical and sub-tropical climate provide appropriate environment for raising annual, biennial and perennial crops as inter and mixed crops in high density multi species cropping systems. Ginger, turmeric, coffee, banana, cocoyam, and cereals like upland paddy, pulses like red gram, vegetables, flowers, fodders and other annuals are intercropped with pepper. Pepper intercropped with coffee, arecanut and coconut. Black pepper can be grown as a suitable and profitable intercrop in areca nut garden under Sub-Himalayan Terai Region and tea gardens of Assam.

Cardamom, a shade loving plant grown under tall forest shade trees and it offers great scope as a mixed crop in coffee plantations in the tropical forests, besides it can grown under arecanut and coconut plantations. The tree spices such as clove, nutmeg, cinnamon and allspice can inter planted with cardamom. The shade trees provide support to trail black pepper. Vanilla can also be inter planted with suitable support.

Ginger and turmeric are intercropped with vegetables, cereals, oilseeds and other crops. These can also be grown as mixed crop with castor, redgram, finger millet and maize. As these spices requires partial shade, they can be grown as an under crop in coconut, arecanut, rubber, orange, stone fruit, litchi, guava, mango, papaya, loquat, peach, coffee and poplar plantations. They are the most favoured crop components under agroforestry. Intercropping seed spices with ber plantation also found better for realizing higher system productivity, net return and BCR.

Crop-specific micronutrient formulations for major spices

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

Pre-monsoon irrigation for enhanced pepper productivity

Irrigation of black pepper vines around the basin from March to May @ 50-60 L/ vine at an interval of 15 days can markedly enhance spike length, number of spikes, oleoresin content and berry yield. This technology promotes uniform spike initiation and reduces the spike shedding due to late monsoon and guarantees good crop.

Plant health management technologies

Trichoderma harzianum, a biocontrol agent against Phytophthora

The production of black pepper *Piper nigrum* is hampered by *Phytophthora* foot rot caused by *Phytophthora capsici* not only in India but also in other black pepper growing countries. The talc based bioformulation based on *Trichoderma harzianum* can be used successfully to manage *Phytophthora.* It can be used in integrated pest management as well as under organic farming system in crops like black pepper, ginger, cardamom and turmeric. There is a great demand for the product and IISR has already issued several licenses for its commercial production.

Pochonia chlamydosporia, a biocontrol agent against nematodes

Plant parasitic nematodes, especially root knot nematodes (*Meloidogyne* spp.), are widely prevalent in black pepper gardens of South India and cause significant damage to the plants. Currently they are managed through application of nematicides like phorate and carbofuran. Biological control of root knot nematodes, therefore, is highly relevant in this context. *Pochonia chlamydosporia*, a known nematode biocontrol agent, is a facultative nematode parasite. It proliferates in the rhizosphere, colonizes the egg masses of root knot nematodes, parasitizes their eggs and sedentary females. The technology is ready for transfer and commercialization to potential entrepreneurs as there is an upcoming demand for *Pochonia* in the event of ban on many popular nematicides.

PGPR formulations for spices

Ginger: PGPR technology is a talc formulation developed and tested with a plant growth promoting Rhizobacteria (PGPR), *Bacillus amyloliquefaciens* specific to ginger. The major advantages observed are enhanced nutrient mobilization and nutrient use efficiency, increased growth, yield and assured crop protection against soft rot disease. It may be extended to other crops and bioagents too.

Black pepper consortium: The consortium is a combination of three micro organisms namely *Micrococcus luteus*, *Enterobacter aerogenes* and *Micrococcus* sp. It is ecologically safe, increases growth and yield and enhances nutrient mobilization and efficiency in black pepper. It can be applied both in black pepper nurseries and under field condition as soil drench.

Novel and smart delivery of biocontrol agents through encapsulation

The above said bio agents are successfully encapsulated and the delivery of a plant growth promoting rhizobacteria for growth promotion and disease control in ginger and black pepper are made in to bio capsules by ICAR-IISR. The encapsulation process is simple, does not require sophisticated equipments and comes at low investment. Other advantages include reduced cost and easy handling and transport, no harmful by products, less requirement of inorganic and inert material, storage at normal temperature and more importantly, enhanced shelf life. Besides, this encapsulation technique can be used to deliver all kinds agriculturally important microorganisms *viz.*, N fixers, nutrient solubilizers/mobilizers, Plant Growth Promoting Rhizobacteria (PGPR), *Trichoderma etc.* Patent for this delivery process has been filed and the technology has been commercialized by providing non-exclusive licenses to private companies.

Seed coating using PGPR

PGPR technology is a novel process of coating efficient strains of PGPR on seeds. The components consist of live PGPR, inert material and a binding agent. The process is done at a particular temperature which is congenial for the organisms to survive and the coated seeds can be stored at the room temperature. Seed spices such as coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), fennel (*Foeniculum vulgare* M.) and fenugreek (*Trigonella foenum-graecum* L.) cultivated predominantly in states of Rajastan and Gujarat have major constraints like low germination, slow initial growth and high susceptibility to diseases and frost. PGPR are a wide range of root colonizing bacteria with the capacity to enhance plant growth by increasing seed emergence and crop yield. It was observed that seeds coated with PGPR exhibited longer shelf life and germination and remained intact even after 1 year of storage. The technology has wide applicability and can be extended to vegetable seeds imparting the appropriate crop specific bioagent.

Diagnostics for diseases infecting spices

Black pepper is infected by two viruses (*Cucumber mosaic virus* and *Piper yellow mottle virus*) whereas cardamom is infected by two viruses (*Cardamom mosaic virus* and *Banana bract mosaic virus*) which are systemic in nature. Once infected, viruses cannot be eradicated by any means including chemicals. Hence it is advisable to use certified virus-free material for planting. Loop-mediated isothermal amplification (LAMP) and real-time LAMP based assays were also developed for quick and sensitive detection of virus diseases of black pepper and cardamom. The technology can be used for certification of mother plants/planting materials of black pepper for freedom from viruses.

A strain specific and sensitive technique based on Real Time Loop Mediated Isothermal Amplification (Real Time- LAMP) was developed for detecting race 4 strain of *Ralstonia solanacearum* causing bacterial wilt in ginger. The method can be used to index both soil, water as well as seed rhizomes. The time taken for detection is only 3-4 hours and the detection limit is 10^3 CFU/g of soil or rhizomes. The technology can be easily adopted in field for pathogen-free site selection as well as selecting disease-free seed materials for planting.

Processing and value addition

- A simple technique of hormone treatment was developed to split open nutmeg fruits without exposure to soil to prevent aflatoxin contamination in nutmeg. The methodology involves harvesting physiologically mature fruits and treating with 500 ppm ethrel (2-Chloroethylphosphonic acid) for 10 minutes and storing making them to 90-100% split in 18-20 hours.
- Developing a mechanical unit for production of white pepper from black pepper with a dry recovery of 68.7%. The capacity of the pulping unit was 125 kg/h.
- A renewable solar energy cooking unit was developed for turmeric curing. It has solar thermal collectors with curved parabolic mirrors which concentrates solar radiation on to a central pipe called as the receiver. The unit has a cooking vessel of capacity 50 kg turmeric/batch and complete cooking of turmeric could be achieved in 45 min.
- A hand-held electronic nose was modified with suitable sensor array for determining quality of cardamom to graded into low (<4.0%), medium (4.0-6.0%) and high (>6%) based on essential oil content.
- Antioxidant activity of spices was tested for its nutraceutical potentials. Methanol extract of Malabar Excel was found to be highest for all the assays followed by *P. colubrinum*. Hexane extract of *P. colubrinum* showed high cytotoxicity under *in vitro* conditions on cervical cancer cell line CaSki by MTT assay.

Spice processing through entrepreneurship development

ICAR-IISR has set up a business planning and development (BPD) unit, a business incubation centre designed to promote entrepreneurs and equip them into profitable business ventures. The BPD unit is presently giving more impetus to entrepreneurship development and commercialization with respect to technologies developed by IISR. The BPD unit has facilitated the non-exclusive licensing and commercialization of the designer micronutrient formulations developed for black pepper, ginger and turmeric.

The high-end spice processing facility established at ICAR-IISR Farm, Peruvannamuzhi is compliant with national and international quality requirements. The unit is equipped with state of the art facilities for cleaning and grading black pepper and production of spice powders. This unit will not only cater to the needs of the farmers in the spice growing belt where it is situated but will also serve as a model unit for the benefit of spice growers and entrepreneurs all over the world. ICAR- IISR periodically organizes entrepreneurship development programme (EDP) for the stake holders to identify suitable entrepreneurs for steering forward the operations of the processing facility.

New perspectives in spices research

The estimated growth rate for spices demand in the world is around 3.2%, which is just above the population growth rate. The forecasted population increase is up to 1619 millions in 2050 with increased GDP and per capita food spending. The per capita demand for spices is expected to increase many fold by 2050. The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148 g, 53 g, 1.22 kg and 1.63 kg, respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7-5.7 folds from the present levels. Therefore, we need to continuously strive to increase spices productivity by enhancing input use efficiency, and reducing post harvest losses with an eye on reducing the cost of production.

Overall, the main researchable areas in spices should encompass:

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

While there is little scope for enhancing the area under spices in the traditional belts of the country, we need to focus on newer niches where the potential for spices cultivation is immense like spreading to non-traditional areas in the North Eastern Hill Region (NEHR) where opportunities and skill sets for the future exists. In addition, Nurturing and improving sound techniques on precision farming, protected cultivation and urban horticulture can help in surmounting the challenges posed by other growing countries. A well reasoned and cohesive application of cutting edge research, institutional support for development and creative policy initiatives can ensure doubling farmer's income in spices sector in the country.

SESSION I:
STATUS OF SPICE INDUSTRY IN INDIA

LEAD LECTURES

Status and challenges of spice production in Meghalaya

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The state of Meghalaya came into existence on 2 April 1970. It emerged as a full-fledged state within the union of India on 21 January 1972. It is tucked in the North East of India, covering an area of 22429 sq. km. It comprised of only three districts at the initial stage but now divided into eleven districts namely East Khasi Hills, West Khasi Hills, South West Khasi Hills, Ri-Bhoi district, East Jaintia district, West Jaintia Hills, East Garo Hills, West Garo Hills, South West Garo Hills, North Garo Hills and South Garo Hills. It is situated between 25.47°/25*1' and 26.10°/26*5' north latitude and 89.45°/85*49' and 92.47°/92*52' east longitude at an elevation ranging from three hundred meter to over one thousand eight hundred meters above sea-level (MSL).The temperature range is approximately between 2 to 36 degree centigrade depending upon the altitude which ranges between 300 mts above mean sea level (MSL) to 2000 mts above MSL. Meghalaya is amongst the heaviest rainfall areas in the world with an annual average rainfall of 11,000 mm during the period of 1980-91. Predominantly mountainous, lying between the Brahmaputra valley in the north and the Surma valley (Bangladesh) in the south, the total population of the state as per 2001 census was 2,306,069.

Agriculture is the main stay of the people of the state where 80% of the population of the state depends on agriculture for their livelihood. Whereas, by far the major part of the land lying barren may not be suitable for cultivation under traditional systems and practices, yet the general topography being not very steep, there is a good possibility of using it for horticultural crops, especially fruit trees. The rainfall is very much adequate ranging from 2000 to 5000 mm. The Cherrapunjee - Mawsynram belt on the southern slopes of the state has the distinction of having the world's heaviest rainfall mostly confined during the month from April to September. The soil of the state is mostly red loam and is generally acidic in nature, comparatively rich in organic matter and nitrogen but poor in phosphorous and medium in potash content.

Due to the natural attributes mentioned above, the state already enjoys an importance of its own from the horticulture standpoint. Different horticultural crops ranging from temperate fruits to tropical crops can be cultivated and thus there is immense scope for horticultural development. Lack of road communications to the horticultural important villages and un-organized marketing facilities are the main drawbacks which hamper economic progress of the state.

Meghalaya has natural advantages in growing a variety of spices of which the prominent ones are turmeric, ginger, chilli, black pepper and bay leaf. Except for bay leaf, which is a forest product the other spices are cultivated. Large cardamom has been introduced recently and is slowly becoming popular with the farmers.

Ginger

The crop is well suited under the Meghalaya condition grown in almost all parts of the state. Its cultivation is expanding over the years and less fibrous improved varieties like Nadia, Maran, Suprabha, Varada and Poona are being popularised among the farmers. However in Garo Hills, the local variety called *"Tura/Tama"*, which is fibrous, is

more popular as it is less susceptible to soft rot disease. Ginger varieties grown in the state are Nadia, Varada, Khasi Local, Tura Local, Jamaica, Mookydur, Sying Met, Sying Makhir, Ing Bah, Sying Smoh.

Among the above mentioned ginger varieties grown in the state, Nadia and Varada varieties are in high demand in the market as they contain less fiber (4.5%). Rhizomes of these varieties are very fleshy, juicy and suitable for conversion into candy, cube preserves, drinks powder making *etc.*, thereby increasing its potential for export especially to the neighboring countries likes Bangladesh.

Ginger is cultivated in the hills along the slopes as a single crop or mix cropped in jhum Cultivation. However, almost all the jhumiahs are not accustomed to the use of chemical fertilizer/pesticide and as such ginger production in the state can be termed as *"organic ginger"* which would have another advantage for export besides fetching remunerative prices to the growers.

It is to be noted that the planting material of ginger *"Nadia"* and *"Varada"* varieties are very much scarce in the north eastern states. Availability of breeder/foundation seed is very difficult which could have multiplied in the Departmental Farms since seed rhizomes are being used for years together from the foundation seed collected earlier, the purity of the seed is very remote which may affect productivity.

Turmeric

Turmeric can be grown in all the districts of the state as the soil and climatic condition is very much suitable for its cultivation. In fact, Meghalaya's turmeric is well known throughout the country especially for its excellent quality. The turmeric variety *"Lakadong"* is grown all over the State but that which is being grown in certain part of Jaintia Hills district of the state is very much superior because of its high curcumin content (7.6%). The reason for high curcumin content of Lakadong variety of turmeric from Jaintia Hills may be due to the climatic condition, physical and chemical properties of soil and other ecological factors favoring the proper growth and development of good quality rhizome. The crop is grown as pure crop. However, in Jaintia Hills, the crop is intercropped with maize where as in some parts of the district turmeric is also intercropped with other crops in jhum cultivation. Thus the yield is affected and the overall production is comparatively low.

Turmeric is grown in the state without using chemical fertilizer/pesticides. Thus the production could be called as *"organic turmeric"* which may be an opportunity open for export. In Jaintia Hills, a good quality of turmeric powder is produced in traditional method after sun drying which fetches good price but due to its un-organized market, its distribution is very poor and farmers are not getting the price deserved by them. If properly organized the demand for its product in powder form would be higher and thereby the state would have earned good foreign exchange.

Chillies

Chillies are cultivated both in the plains bordering Assam/Bangladesh and also in the jhum cultivation as a mixed cropped. However, local chillies are quite popular due to their high pungency. The local variety called *"Bird eye"* chilly is immensely potential for export for its highest heat value. Although the production is very much negligible, most of the chillies produced in the state is sun-dried and marketed within and outside the state. The price is highly dependent on local traders due to un-organized market which contributes to low area and productivity.

Black pepper

Black pepper is a plant of humid tropics which requires adequate rainfall and humidity. The hot humid climate of sub-mountainous tracts facing Bangladesh and Assam are ideal for its cultivation.

High yielding varieties like Panniyur- I, Karimunda are introduced in the mid fifties into the, then state of Assam is quite popular and multiplied in most of the districts. It is grown using standards like arecanut tree, *Erythrina indica*, simul, mango, jackfruit tree, silver oak and other forest trees. However, its cultivation has not been standardised by the farmers which leads to low production. But the farmers are not using any chemical fertilizers/pesticides, thus there is a scope for export where organic products are being encouraged. The price of sun-dried black pepper varies from Rs 30 to Rs. 200 per kg in the local market due to poor organisation of the market and solely depend on traders. One of the important problem of black pepper in the area is that most of the pepper gardens consist of good percentage of unproductive senile vines, severe incidence of wilt diseases, flea beetle and scarcity of rooted cuttings of high yielding varieties.

Challenges of spice production in Meghalaya

- Geo-physical conditions limit horizontal expansion of cultivable land.
- Lack of adequate infrastructure for large-scale production and distribution of quality planting materials of the released varieties.
- Prevalence of traditional agricultural practices resulted in low productivity and environmental diseconomies. The shifting cultivation (jhum) is one such system.
- Over-dependence on monsoonal rains with poor irrigation infrastructure.
- The productivity is also low due to land tenure system prevailing in the region because the farmers do not feel any sense of belonging to the land and therefore, they do not undertake adequate management practices.
- Resource poor farmers having low produce holding capacity.
- Low productivity due to cultivation of varieties of poor genetic potential with regard to yield and quality parameters.
- High rainfall received in the region causes heavy infestation with weeds, pests and diseases and leaching of nutrients.
- Zero nutrient management and poor plant protection measures resulting in considerable yield losses.
- Non adoption of recommended cultural practices, as well as soil and water conservation measures.
- Lack of proper storage, processing facilities and appropriate post harvest technology.
- Non-existence of organised marketing system / growers association.
- Frequent fluctuations in prices of the spice crops like in ginger.
- Non-availability of seed agencies to supply certified planting material to the state.

Status and challenges of spice production in Nagaland

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Introduction

Indian spices are as old as human civilization itself. Almost every early religious book like the Vedas, the Bible and the Quran mention Indian spices in their writings. It was in the search of the sea-route to this spice-rich country that many great continents and countries were discovered by the early explorers. Spices constitute an important group of agricultural commodities, which are virtually indispensable in the culinary art. Spices may be bark, buds, flowers, fruits, leaves, rhizomes, roots, seeds, stigmas and styles or the entire plant tops.

India thus, is aptly known as the "Land of Spices" given the fact that over 100 different spices are grown in an area of 3.4 million hectares and produces 8.2 million tonnes of spices annually and exports around 180 spice products to over 150 nations. The estimated growth rate of spices is 3.19%, and the world spice trade is expected to touch 18 billion and that of India is US$ 5 billion by 2020. Thus, the spices market in India seems quite rosy and promising.

The North East Region including Sikkim is a rich mangrove of spices and has acquired GI tag of spices like Mizo Bird-eye chilli in Mizoram, Naga Mircha in Nagaland, Karbi-Anglong ginger in Assam and large cardamom in Sikkim. The area and production of major spices (2016-17) in the North East are as indicated in the table below.

Sl. No	Spice	2016-17	
		Area (ha)	Production (tons)
1.	Ginger	55,683	4,00,207
2.	Turmeric	33,920	1,18,906
3.	Garlic	30,137	57,257
4.	Chilli	37,740	44,252
5.	Large cardamom	35,350	8,166

Status of spices in Nagaland

Nagaland holds a special position on the spices map owing to the quality of its spices, which have won wide acclaim due to the quality as well as health benefits. Spices in the state have been grown under default-organic conditions as the region is blessed with varied agro-climatic conditions and rich soil, which are favourable for organic farming. The availability of wide genetic resource base and varying production systems in the state ensures sustainable production of different spice crops. The state has acquired GI tag of Naga Mircha which is the first crop of the state to be given the GI Tag.

A wide variety of spices are grown in all the districts of the state, amongst which Naga Mircha, ginger, turmeric and large cardamom are the major crops, which are largely grown as inter-crops in the jhum Fields. Spices in the state cover an area of 15.69 thousand hectares and the production is estimated to be 105 thousand tonnes. The area and production of major spices in the state are as indicated below.

Sl. No	Spice	Area (ha)	Production (tons)
1.	Ginger	4535	43688
2.	Turmeric	642	10147
4.	Chilli	847	5101
5.	Large cardamom	3734	1869

Nagaland has the key distinct advantage of being a default-organic, meaning the crops are grown naturally without any chemicals and pesticides which can be transformed into a commercial organic hub and is placed in a strategic location for export to ASEAN countries. Ginger, turmeric, large cardamom and Naga Chilli are the key potential crops with export potential which can be capitalized upon by the state and can turn the table around for doubling the farmers' income.

Challenges in spices production in the state

- Lack of quality planting materials for spices.
- Declining productivity of spices due to deteriorating soil health.
- Biotic and abiotic stresses due to climate change.
- Increasing cost of cultivation.
- Non-availability of farm labour.
- Majority of the farmers of the state are small and marginal farmers with small and scattered land holdings. Thus commercialization of spices becomes difficult due to the diversification of their farms for meeting the household requirement.
- Lack of adequate storage facilities.
- Lack of adequate facilities for processing and value addition.
- Lack of exportable surplus at the farm gate level.
- Lack of organized markets and lack of market power to the small holder farmers leads to exploitation by the middle men.
- High transportation cost and unavailability of transport subsidies.
- Lack of grading and standardization.

Future thrust and conclusion

Spices no doubt, have the potential to double the farmers' income in the state given the advantages the state has to offer for spices production. Yet, the fact remains that the state is still lacking in terms of meeting the demand-supply chain and emphasis should be given to increasing the productivity of the spices which can be done through a number of well-thought and well-designed strategies.

There is a need to shift our focus to the seed production programme for spices through the support of the Government, SAUs, ICAR and other research institutions for production of quality planting materials, in addition to climate change resilient varieties which will help in improving the productivity. The default-organic status of the state needs to be capitalized upon by developing a simplified and affordable organic certification system for the benefit of the farmers as well as the state and certain arrangements need to be done for exporting the organic spices to the outside markets.

Cluster approach in spices production should be encouraged which can help in the easy formation of FPOs and improve the collection and transportation of spices, thereby reducing the transportation cost of the farmers. In addition, policy makers may need to re-think on the present policy regarding transport subsidies and make available transport subsidies at least for the FPOs. There is a need to reform the present marketing system in the state and market channels through APMC/NSAMB should be organised for spices with facilities for primary processing and value addition for spices.

There is a need to create awareness and impart extensive trainings to the farmers for adopting scientific method of cultivation of spices including package of practices, post harvest handling, grading and sorting, value addition, packaging *etc.* which will go a long way in improving the quality of the produces and products for generating better income for the farmers.

There is still need for improvement in terms of production through supply of disease free planting material and adoption of modern scientific techniques. The state is default-organic by nature and has natural advantage in terms of large tracts of land suitable for spices cultivation. The vision for the state should be to become a premier supplier of quality spices in both raw and processed form to the large consumer segment of the global spices market and to transform the state into an "Organic Hub" which can only be achieved if all the stakeholders right from the producers to the policy makers and NGOs come together and work towards achieving this vision which will in the end, serve to double the farmers' income by 2022.

Spices in Nagaland at a glance

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Nagaland state comprises of 11 districts bounded by Assam in north and west, Arunachal Pradesh in north, Myanmar in east and Manipur in south. The altitude ranges from 150m to more than 3800m above msl. Total geographical area is 16579 sq km of which only 8% is plain land and the rest is constituted by undulating and hilly terrain. The state represents wide variation in climate ranging from cold to warm pre-humid and receives mean annual rainfall exceeding 2000 mm per annum. The soils of the region are usually rich in organic matter and acidic to strongly acidic (pH 4.2- 5.0) in reaction and thus suitable for growing different rhizomatous and tree spice crops. The state faces unpredictable high rainfall and consequently the nutrient depletion and the erosion. Agro-climatically the region is known for its wide diversity representing temperate, subtropical and tropical areas. The diversity within a single region provides ample scope for growing a large number of crops. India is commanding a formidable position in the world spice trade with 47% share in volume and 40% in value. India is always hailed as major producer of spice, but off late in the world spice market, it is facing stiff challenges from countries like Indonesia, Malaysia, Madagascar, Vietnam, China *etc*., which are also producing and exporting to the international market. Spice crops are an important commodity which play major role in economy of the country. Nagaland has a tremendous potential for production of spice crops. The climatic condition of the state is highly suitable for cultivation of a large number of spices such as ginger, turmeric, chilli, black pepper, cinnamon, large cardamom, leafy coriander, and garlic, Kokum, Cinnamon *etc*. Among spices, ginger, turmeric and large cardamom are the main cash crops supporting the livelihood and improving the economic level of many growers of the state. It is anticipated that the state can create exportable surplus at competitive prices so that the top position could occupied by national market for organic spices would be maintained. The total area under different spices in the state is 9.77 thousands ha with a production of 39.16 thousand tonnes with 0.64% productivity share in the country (Spices Board 2015). Among spices, ginger cultivation has increased many folds followed by large cardamom, black pepper and turmeric. Ginger is already a well established cash crop in Nagaland however, large cardamom cultivation has come up well in most of the districts where large cardamom is the major spice crop grown commercially since implementation of MIDH programme in the states and intervention by Spices Board of India.

Ginger, turmeric & large cardamom cultivation

These crops prefer warm, humid climate with well-drained soils like sandy or clay loam, red loam or laterite loam for their successful growth. In the state, ginger and turmeric are grown as rainfed crops while in other parts of the country, they are grown both as rainfed and irrigated crop. One of the most significant features of the agriculture in the state is the prevalence of jhum cultivation in large parts. In the hill tract, ginger and turmeric are generally cultivated in the jhum fields. Under this, large tracts of hills are demarcated and the forest in the region is cleared by burning and such land thus available is utilized for cultivation of mixed crops with major cereal crops which are being burnt before sowing of seed rhizomes and seeds of major crops. The burning of field helps in reducing the weed growth, soft rot disease and increase the availability of certain plant nutrients. This jhum land is abandoned after 3-4 years and new piece of land is cleared in a similar fashion. In the region usually the seed rhizomes are stored in the pit under soil cover after harvest. By March-April, when the rhizomes start sprouting, they are taken out and planted in the fields.

Large cardamom farming as an under storey crop in hill slopes is an unique traditional production system under alder tree plantations which is most important nitrogen fixing tree in the subtropical hills of Nagaland. In hill slopes large cardamom is considered as a high value cash crop followed by ginger and King Chilli. In recent years, black pepper is also showing promise and organic production is possible to a limited extent. Large scale planting material production technique developed by research system should be popularized in this region. It is reported that large cardamom growers are experiencing difficulty in drying capsules as sunlight is received for a short duration only and hence, the dried capsules are not getting attractive pink colour which has more demand.

Marketing aspects of spices

Spices growers have no option other than selling to nearest merchant, buyer, village shops or some times to terminal market immediately after harvest when the price is at the lowest because there is no government intervention in spice market with regard to marketing or providing reasonable price to farmers.

Marketing the produce to pre-harvest contractors is also prevalent in north east particularly, of ginger and large cardamom. In this, farmers receive advance payments immediately after acceptance of the offer. The Naga tribal farmers are naturally risk averters and prefer to be safe, they tend to prefer an inferior outcome that is relatively certain to the prospect of a higher average return with a greater degree of risk attached. Markets are thin, unorganized and lack of market access to the small holders makes market more risky for them. Lack of finance also undermines the capacity of private sector to invest in its trading enterprise and limits the scope and scale of market operations. The real challenge for the state is to devise options that mitigate the risk of the farmer who produces and markets commodities that are small in quantity, have high cash costs, require credit to finance the cash purchases, and are perishable.

Global warming and climate change aspects of spices production

Global warming and climate change are the greatest concern of spices production. The established commercial varieties will perform poorly in an unpredictable manner due to aberrations of climate. Commercial production of horticultural plants particularly grown under open field conditions will be severely affected. Due to high temperature, physiological disorder of horticultural crops will be more pronounced. Air pollution also significantly decreases the yield of several horticultural crops and increases the intensity of certain physiological disorder. Hence there is a need to protect these valuable crops for sustainability against the climate change scenario. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation *etc*. To sustain the productivity, modification of present horticultural practices and greater use of greenhouse technology are some of the solutions to minimize the effect of climate change. Development of new cultivars of ginger, large cardamom tolerant to high temperature, resistant to pests and diseases, short duration and produce sustainable yield under stress conditions, as well as adoption of hi–tech horticulture and judicious management of natural resources will be the main strategies to meet this challenge. The state with diverse soil and climate comprising several agro-ecological regions provides ample opportunity to grow a variety of spice crops which form a significant part of total agricultural produce in the country.

The knowledge about the impact of climate change on spice crops is limited. Addressing problems of climate change is more challenging in spice crops compared to annual food crops. The issues of climate change and solution to the problems arising out of it requires thorough analysis, advance planning and improved management. The crop productivity is subjected to number of stresses and potential yields are seldom achieved with stress. Climate change is predicted to cause an increase in average air temperature between 1.4 ^{0}C and 5.8^{0}C, increases in atmospheric CO2 concentration, and significant changes in rainfall pattern. The present challenges like global climate change, water and soil pollution, less water availability, urbanization *etc*. add up to the situation. In combination with elevated temperatures, decreased precipitation could cause reduction in availability of irrigation water and increase in evapotranspiration, leading to severe crop water-stress conditions. Some horticultural crops like spices and plantation crops are location specific. In order to sustain our horticultural production with present day challenges we have to have packages to manage abiotic stresses. The nature and magnitudes of stress vary.

The consequences of such rapid change are - global warming, change of seasonal pattern, excessive rain, melting of ice cap, flood, rising sea level, drought, *etc.* leading to extremity of all kinds. Decrease in potential yields is likely to be caused by shortening of the growing period, decrease in water availability and poor vernalization and even total agricultural land will shrink and the available land may not remain suitable for the present crops for too long. Farmers have to explore options of changing crops suitable to weather. In general due to increase in maximum and minimum day temperature and decreasing the annual rainfall the productivity showed decreasing trend in most of the spice crops in north east region. We can see an increase in demand for herbal food and cosmetics due to greater health awareness, rising income, export demands. There is also an overall increase in the demand of spices for consumption both in fresh and the processed form. But with the ever changing environment there are growing concerns for the need of sustainability in all aspects of farming. Depending on the farm location, climate change could affect the spices industry. The issue of climate change and climate variability has thrown up greater uncertainties and risk which imposes constraints on its production systems. The climate change will have many impacts on spices production and quality aspects. A study conducted at ICAR-IISR, Calicut using GIS models have shown that many areas presently suitable for spices would become unsuitable in another 25 years. There would be new areas which are presently unsuitable, become highly suitable for cultivation of spices.

Prospects of spices cultivation

Nagaland state offers immense potential for large scale cultivation of spices. It is estimated that the state of Nagaland can create exportable surpluses. State has the potential to become major organic spice exporting centre if adequate processing and marketing facilities are set up in the spice growing areas. Spices in the state or from the region is blessed with ideal soil and climatic conditions. These spices are amenable to organic by default which results in chemical residue free commodity for domestic as well as export market. High humidity would be ideal to explore commercial cultivation of ginger, turmeric, large cardamom and various tree spices like cinnamon, tejpata/cassia, Garcinia *etc.* in the state. At present, no tree spices are commercially grown in Nagaland, though there is a tremendous potential for growing these crops.

Most of the NE states are having virgin land without any commercial cultivation that is very much suitable for organic cultivation of spices and major spices like large cardamom, black pepper, ginger, turmeric and chillies have larger area in this tract.

Potentials of organic spices in north eastern region:-

i. Minimal or no use of chemical fertilizers and pesticides in the region which makes the region very potential for organic cultivation of spices. Therefore, a major part of this spice growing area can be converted for organic farming.
ii. Area under organic spice cultivation can be instantly recognized and the process of certification will be expedited.
iii. Natural resource of biomass, traditional and indigenous knowledge systems can be exploited and utilized in NER.

Major production constraints of spices in the state

In spite of the fact that ginger is an important and oldest spice crop in Nagaland, no major breakthrough has been noticed in boosting the production and increasing export of ginger. Since it is vegetatively propagated crop, lack of consciousness in selection of high yielding varieties and several characters must presumably have occurred in the past. There had also been interchange of materials, but with all these there has not been tangible increase in the production. Only two major varieties *viz*., Nadia and local pungent ginger are predominant in the state. The major bottlenecks of north east are, shifting cultivation, terrain & small holding, non availability of quality planting materials and other inputs in time, high rainfall, least or no use of fertilizers and plant protection measures, problems of processing and marketing, losses due to faulty storage method and diseases, lack of improved production technologies and management practices and negligence of systematic research and development in the state.

Conclusion

Increasing the productivity per unit area through spice based farming systems, development of varieties with high degree of resistance to biotic and abiotic stresses, development of agro technology towards low input management, precision farming, developing eco-friendly IPM strategies, post harvest technologies with value addition and exploiting medicinal properties of spices, and popularization of proven technologies through extension network are the major areas which needs attention. These technological advancements will bring out the surge in productivity of spices, and 2- 5 fold increase in all major spices, to meet the consumption and export demand. The technologies developed have to be effectively transferred to sustain the spice production and doubling the farmers income in the state and new technologies are required to tackle the emerging challenges like climate change and global warming.

The state has a tremendous potential for the production of spices. There is need to improve infrastructure, extension network, focused research in order to harness the potentiality of this virgin land for quality spice production. It is suggested to form farmers' organizations/ cooperatives both at local level and at the regional level for better marketing of the produce.

Scope and opportunities of seed spices cultivation for livelihood improvement

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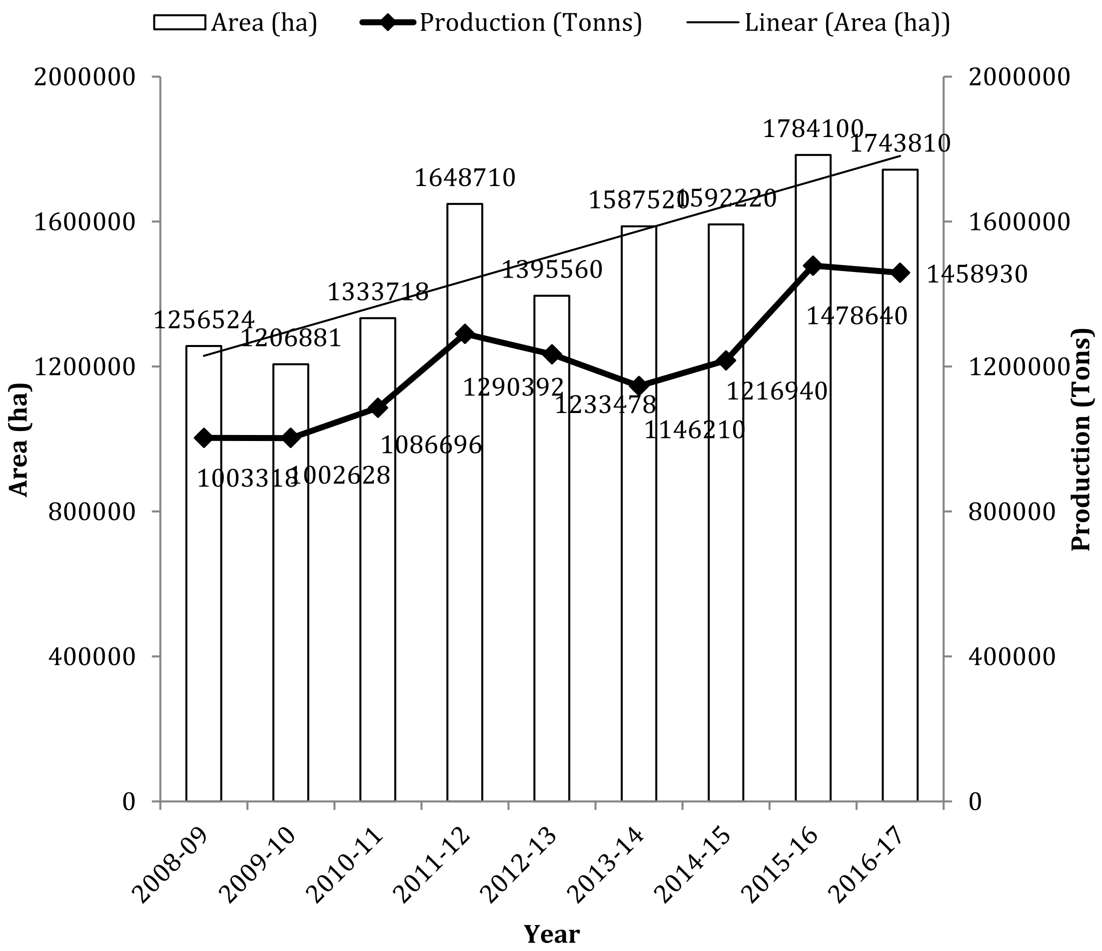
Introduction

Seed Spices are annual herbs, whose dried seed or fruits are used as spices. They are nature's gift to mankind and add flavour to our food in addition to having preservative and medicinal value. A total 109 spices are listed by ISO and 63 spices are grown in India out of which 20 are classified as seed spices. Out of 20 seed spices, ICAR-NRCSS works on 10 most important seed spices namely cumin, coriander, fennel, fenugreek, ajwain, nigella, dill, anise, celery and caraway (NRCSS Vision, 2050). Total area under spice cultivation in India is about 3.54 million hectare and production is about 7.08 million tons (Spice Board India, 2015-16). Out of total area and production in spices, seed spices contribute about 50% of total area and 20% of production of spices in the country. The area under seed spices is about 1.78 million hectares and 1.48 million tonnes (Fig. 1). Cumin (8.08 lakh ha) and coriander (6.2 lakh ha) collectively constitute about more than 80% of total seed spices of our country. Seed spices play a significant role in our national economy because of its large domestic consumption and growing demand for export. The total export of seed spices is worth of more than Rs 2800 crores annually (Fig. 2) out of which cumin alone contributed more than Rs 1900 crores. In India, seed spices are mostly grown in Rajasthan, Gujarat besides Uttar Pradesh, Madhya Pradesh, Punjab, Haryana and some parts of South India. Both Gujarat and Rajasthan account for about 80% per cent area and production in India. The seed spices can be grown in poor soil and water. The seed spices could be one of the options in salt affected area where other crops cannot be grown. These crops require low inputs and the remuneration obtained by the farmers is very high. These crops have opportunities to be grown in those areas to increase the livelihood of the farmers. The price fluctuation of seed spice crops is very low as compared to other crops and growing demand for seed spices in world market indicate a bright future for seed spices cultivation in India.

India is the largest producer, consumer and exporter of seed spices. India is exporting only 15% of its production annually and fulfils more than 50% of world's demand. The seed spices are also grown in different parts of the world covering mainly Mediterranean region, South Europe and Asia. Morocco, Russia and Bulgaria are the major producing countries for coriander; Turkey, Iran and Egypt for cumin; Egypt, China, Romania and Russia for fennel; Morocco and Bulgaria for fenugreek; Iran and Egypt for ajwain; Germany and Hungry for dill; Southern France and China for celery; Bulgaria, Cyprus, Germany, and Russia for anise; Pakistan, Sri Lanka and Egypt for nigella.

A "New India" is the latest national agenda. Prime Minister, in his fourth Independence Day speech, made an appeal with his trademark gesture of both hands pointing towards the gathering: "A new India that would fulfil the dreams of the young and women, and see the income of farmers double by 2022". The seed spices are one of the agriculture commodities that certainly can double the farmer's income.



Source: Spice Board India and DASD, 2016-17
Fig. 1. Status of area and production of seed spices in India

Source: DASD, 2016-17
Fig. 2. Export of seed spices from India

Cultivation of seed spices for livelihood improvement

Use of quality seed of seed spices

The seed replacement rate in seed spices is very low (15%) which is a major challenge for enhancing production and productivity of seed spices. Providing good quality seeds is one of the most important and easiest means to accelerate the productivity of seed spices in the country. Crop status largely depends on the seed materials used for sowing, response of other inputs in crop production depends on seed material used, the seed required for raising crop is quite small and its cost is so less compared to other inputs, which emphasises the need for increasing the areas under quality seed production. It is estimated that good quality seeds of improved varieties can contribute about 20-25% increase in yield. ICAR-NRCSS is producing and distributing quality seeds of seed spices to increase the production and quality of these crops.

Selection of crop varieties for higher yield and quality

Most of the seed spices are grown in the areas where the scarcity of natural resources as well as the condition of soil is poor, so development of varieties which are suitable for these areas is also important. The improved varieties developed so far in seed spices are given below:

Table 2. Improved varieties of seed spices developed by different Institute/University in India

S.No.	Crop	Variety
1.	Cumin	RZ – 19, RZ – 209, RZ – 223, RZ-345, GC- 1, GC – 2, GC – 3, GC – 4
2.	Coriander	Ajmer Coriander -1 (ACr 1), Ajmer Coriander -2 (ACr-2), RCr – 41, RCr – 20, RCr – 435, RCr – 436, RCr – 684, RCr – 446, RCr-728, GCr – 1, GCr – 2, CO- 1, CO- 2, CO- 3, CS- 287, Rajendra Swathi, Rajendra Sonia, Sadhna, Swathi (CS – 6), Sindhu
3.	Fennel	Ajmer Fennel-1 (AF – 1), Ajmer Fennel-2 (AF-2), RF – 101, RF – 125, RF – 143, RF-205, PF – 35, GF – 1 (Gujarat Fennel – 1), GF – 2, GF – 11, Gujarat Fennel-12, CO – 1, Hisar Swarup
4.	Fenugreek	Ajmer Fenugreek 1, Ajmer Fenugreek 2, Ajmer Fenugreek 3, Ajmer Fenugreek 4, Ajmer Fenugreek- 5, RMt – 1, RMt – 143, RMt – 305, RMt-361, GM – 1, CO – 1, Rajandra Kranti, Lam Selection–1, APHU Methi-1, Hisar Sonali, Hisar Suvarna, Hisar Mukta, Hisar Madhavi (HM – 350), HM-219, Pant Ragini, Pusa Early Bunching, Pusa Kasuri
5.	Dill (Sowa)	Ajmer Dill 1 (AD–1), Ajmer Dill 2 (AD–2), GD-1, GD-2, RSP-11
6.	Ajwain	Ajmer Ajwain 1 (AA-1), Ajmer Ajwain 2 (AA–2), Ajmer Ajwain -93 (AA-93), Pratap Ajwain 1, GA – 1, Lam Selelction–1, Lam Selection–2, Pant Ruchika, RPA-68,
7.	Nigella	Ajmer Nigella 1 (AN – 1), Ajmer Nigella 20 (AN-20), Azad Kalaungi (1998), Pant Krishna (2001), Rajendra Shyama, Rajendra Mani
8.	Anise	Ajmer Anise 1 (AAni – 1)
9.	Celery	Ajmer Celery-1, RRL-85-1,

Source: www.seednet.gov.in; http://www.aicrps.res.in/index.php/download-it/varietiesreleased

Use of improved production technologies

Suitable package of practices including efficient water, optimum sowing time, seed rate, nursery management, transplanting, spacing, intercultural practices, weed management, cropping system, intercropping and organic farming practices has been standardized for different seed spices for realizing the optimum potential of improved varieties in different agro-climatic conditions. The production technology for off season cultivation has also been worked out for leafy coriander and fenugreek production. In order to boost up production, it is important to popularize improved and innovative production technologies for adoption by the farmers. In coriander, plastic covered walk-in-tunnel and shade net covered walk-in-tunnel with low pressure drip system was found highly suitable for off-season cultivation for green leaves. Raised bed technology with drip fertigation and plastic mulching has been found effective for fennel, dill, celery and ajwain. The production potential of seed spices is much larger than that has been achieved so far. In the endeavour to meet the increasing demand of seed spices, it is now essential to work out complete package of practices varying across seasons, zones and production systems.

Seed spices are basically low nutrient and water requiring crops and seed spices cultivation is confined to the areas where limited water is available for irrigation. Irrigation efficiency is only to the tune of 30-35%, which can be enhanced to 80% with the use of micro irrigation. Lots of initiatives have been taken to apply water in such a manner which can provide maximum output. When, where and how water should be applied has been worked out. Precise irrigation management practices have been developed for seed spices at NRCSS (Lal *et al*. 2011). Normally, all these crops are grown in flat beds, practice of raised bed sowing may be very effective in saving irrigation water as well as maintaining favourable aerobic condition in the root zone throughout the growing season of the crop resulting in better yields. Among various methods tried, drip irrigation has proved successful in exhibiting high water productivity by saving irrigation water from 25-60% along with 10-60% increase in yield as compared to conventional method of irrigation.

Different cropping systems have been helpful for crop diversification, efficient utilization of resources and making intensive use of inputs for sustainable income to marginal farmers. The diverse favourable agro-climatic conditions of the country provides opportunity to cultivate variety of horticultural crops such as fruits, vegetables including root and tuber crops, flowers, plantation and spices crops and medicinal and aromatic crops. These crops provide additional income to farmers. Intercropping of fennel or with knolkhol in 1:2 ratio followed by fennel/dill with cabbage in 1:1 intercropping ratio is very effective for realising higher yield and benefit. Cluster bean-cumin-summer moong followed by pearl millet-cumin-summer moong cropping sequence is very effective for cumin growers. Intercropping of seed spices in arid fruit orchards has also been assessed and found economical.

However, most of the seed spices are low nutrient requiring crops but fertilizers alone account for 20-30% of the total cost of production. Fertilizer efficiency studies using isotope labelled fertilizers have shown nutrient derived from fertilizer (NDFF) values of 0.5 to 30%. Monitoring soil health and leaf analysis will be useful to ensure a balanced nutrient management and safeguard against hidden hunger. The phosphate rich organic manure (PROM); a value added product by co-composting different organic wastes with high grade rich phosphate in fine size can be useful in many spice crops and is an effective alternative to costly chemical fertilizers. Foliar nutrition method for some of the spice crops has been worked out but there is need to cover more seed spices for high nutrient use efficiency. Besides, use of liquid form of fertilizers through fertigation appears to be promising for deeper application with sizeable input saving. The use of bio-fertilizers, VAM fungi, biological nitrogen fixers and other beneficial microbial agents also need to be optimally used to attain an efficient management.

Seed spices based farming system

Seed spices are important horticultural crops, concentrated in arid and semi-arid parts of India. Seed spices can be accommodated with other crops in different cropping and/or farming systems (Malhotra 2004). Fenugreek can be grown as a fodder crop which is rich in protein. The straw from different spices can be used as a feed for animals by blending it in different ratios. Seasonal vegetables and flowers can be intercropped with seed spices. Following cropping systems can be adopted by farmers to enhance the farm income:

Farming systems in arid and semi-arid regions of India

Gujarat: Cumin, coriander, fennel
Karnataka and Andhra Pradesh: Fennel, coriander, ajwain

Madhya Pradesh: Coriander, fenugreek and ajwain
West Bengal, Bihar, Eastern U.P. and Bundelkhand: Fennel, nigella, and coriander
Other predominant crops of semi-arid regions: Wheat, rice, sugarcane, vegetable, moong bean, urdbean, pea, pigeonpea,
Live stock components of semi-arid regions: Buffalo, cow, goat, sheep, fisheries, poultry

Effective plant protection measures in seed spices

Insect pest management

a. Biological control

Seed spices attract large number of predators and parasitoids due to its specific aroma, nectar and pollen. The population of parasitoids was found to increase with the increase in temperature in Rajasthan and Gujarat condition. The parasites *Aphaleeinus kurdijmovi* occurs regularly, reaches to its maximum (98%) which was observed during November-December. On artificial release, the parasitism increases gradually and reaches to maximum in 30 days (Kumaresan *et al*. 1988). For managing noctuids moth larvae under field conditions, 4-6 inoculative releases of egg parasitoids like *Trichogramma Chilonis*, *T. brasiliensis* @150000 parasitoides/ha or starting at first appearance of the moths at 1-15 days interval is found useful. Release of larval parasitoids such as *Chelonus blackburni*, *Bracon brevicornis*, *Telenomus heliothinae*, *Carcelia illota, Coteria kazat* or *Campoletis chlorideae*, would take care of the already hatched larvae. *Coccinellids* consist of major predator found feeding on various sucking pests of seed spices. Predatory bird myna (*Acridotheres tristis*) was also found feeding on the aphid. The other common predators of aphids are *Chrysoperla carnea*, *Episyrphus balteatus* and *Ischiodon scutellaris* (Singh 2007; Mittal & Bhutani 1994).

b. Botanicals

Application of neem based commercial formulations like Neemarin at 1% and seed extract of neem (*Azadirachta indica*), karanj (*Pongamia* sp.), buken (*Melia sp.*) and pride of India (*Lagerstroemia indica*) reduce aphids population by 50% within 7 days of application (Singh 2007). It was observed that 80% reduction of aphid *Hyadaphis coriandri* population on coriander crop through spraying of 1% neem oil and achieve highest grain yield (983 kg/ha). In cumin, aphid *Myzus persicae* population was reduced by more than 50% for 15 days with the application of 5% neem seed kernal extract (Sharma *et al.* 2007).

c. Chemical control

In cumin, spraying of phosphomidon (0.03%), and monocrotophos (0.03%) at 2 week intervals after first appearance of aphids provide effective protection. Sharma *et al.* (2007) found two applications of dimethoate (0.03%), thiomethoxam (0.025%), imidachlorprid (0.005%) and acephate (0.037%) reduced more than 90% of aphid population (*Myzus persicae*) in cumin in 3 days of treatment and produced 40% more yield in comparison to untreated plot. Two spray of carbosulfan 25 EC at 1250 ml/ha. was found to be optimum for the control of sucking pests in cumin, especially aphids and white flies (Ameta & Gupta 2007). Thrips (*Thrips tabaci* and *Scirtothrips dorsalis*) and mites on coriander were controlled by use of monocrotophos (0.5 kg/ha) and chlorpyriphos (0.05-1.0%) (Rao *et al*. 1983). Effective management of *Spodoptera litura* and *Helicoverpa armigera* on cumin, coriander, fennel fenugreek and nigella was achieved by application of monocrotophos (0.05%) followed by aldicarb (0.2%), fenvalerate (50 g ai /ha) or endosulfan (700 g ai / ha) after 10 days.

Management of major disease of seed spices

Although seed spices are not very much affected by diseases as compared to other crops but several diseases reduce the yield and quality of seed spices, which need to be controlled to enhance productivity. Diseases like wilt, blight and powdery mildew in cumin; wilt, powdery mildew and stem gall in coriander; blight and gummosis in fennel, and powdery mildew, downy mildew and phytoplasma in fenugreek frequently attack these crops causing heavy loss of yield and deteriorate the quality of produce. Though the package of practices for the control/ management of each of these diseases have been formulated but still diseases like wilt (cumin and coriander), root rot (fenugreek) and gummosis (fennel) are difficult control completely. Concerted efforts are needed to evolve appropriate technologies for their effective control or varieties which can tolerate or resist these diseases.

Scope and opportunities for seed spices cultivation in poor and problematic soils

The seed spices can be grown successfully under saline/alkaline/acid soils, eroded lands, low fertile soils, limited soil moisture conditions and metal polluted soils. These seed spices not only thrive well under these odd situations but also improve them by following means. Some seed spices such as fennel and coriander have potential for hyper accumulation of salts resulting in reclaimation of saline/sodic soil. Seed spices could be successfully grown in heavy metal polluted soils and under atmospheric pollution as substitutes for some other edible crops and they remove appreciable amount of heavy metals by hyper accumulation.

Scope for organically produced seed spices

Consumers of spices especially importers of late are very health cautious and are always increasing the standards with respect to quality produce and pesticide residue free spices. Hence, scope for organically produced spices is increasing regularly and consumers are paying premium price for organic spices. There is an ample scope in NEH region to produce organic spices as most of spices grown area in NE is organic by default.

Post-harvest management and value addition

Lot of work is to be done under this sector as seed spices are used in many food products and needs standardization. Even neat and cleaned graded spices are fetching more prices in the market. Similarly packaging is also playing its own role for improving and/or maintaining quality of spices under storage. Spices in attractive consumer packs and gift packs are having good market. Products like biscuits, soft drinks, chews, powders, cryo-powder, blended products, oleoresins, essential oils, extracts, perfumes and many more can be developed by the use of different spices for value addition.

Conclusion

Seed spices are high value, low volume, low input crops grown more or less all over the country including NEH region. These crops can easily be grown in small and marginal land holdings which prevail in most parts of the country particularly in NEH region. Diversification towards these crops may be one of the best options for livelihood improvement. Quality produce with higher productivity can be achieved by following the Good Agricultural Practices and Good Manufacturing Practices. Production of these agriculturally important commodities by scientific means can do wonder both for growers and consumers. Post production scenario is also having bright future in these commodities and further, value can also be enhanced by proper handling, processing and development of novel products.

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Growing black pepper in tea gardens of North East India - A sustainability initiative by Amalgamated Plantations

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Introduction

Amalgamated Plantations Private Limited (APPL previously known as Tata Tea), a Tata Enterprise is the 2nd largest tea producer in India and has its operations spread across 21 tea gardens in Assam and 4 gardens in Dooars region of North Bengal covering almost 24000 hectares and employing almost 31000 workers producing 40 million kgs of CTC and Orthodox tea.

Apart from core business tea, APPL has forayed into commercial plantation business in the area of agri-crops and spices with an aim of optimizing land value.

Growing pepper in tea gardens

While it was the erstwhile Tata Tea Ltd that took the lead in this respect, more and more tea companies are looking at black pepper as an additional crop.

Intercropping black pepper in tea gardens in Assam was started by erstwhile Tata Tea way back in 1989 in few tea estates and in between 1990 to 2000 on an experimental basis. But from 2009 onwards, Amalgamated Plantations (a Tata Enterprise) again started re-focusing on this crop and from 2012 onwards actual work of pepper started in all the 25 tea estates.

In 25 tea estates of APPL , there are almost 7.50 lakh shade trees out of which 5.00 lakh shade trees have been planted with pepper vines and pepper planting in 100 % shade trees is planned in a couple of years. The current total black pepper production of APPL is 60 MT from 1 lakh matured vines and the production will increase in the years to come; as more number of younger vines will come into production.

Tea has mixed shade tree species. To avoid monoculture a suitable mixture of shade species is selected. Shade trees are planted to provide natural shade to tea bushes and protect them from seasonal fluctuations in temperature. The common shade species are *Albizzia odoratissima, Albizzia lebbek, Acacia lenticularis, Derris robusta* planted at a spacing of 36 feet x 35 feet, which can accommodate approximately 80 to 85 shade trees per hectare.

A major advantage of pepper is the inter-cropping, *i.e*. both tea and pepper can co-exist without interfering each other. Also, the efficient use of land and judicious deployment of labor can be achieved. Pepper can be easily grown because soil and climatic conditions of this region have been found to be ideally suited for it and it can become a bonus crop or a companion crop.

Seeing the benefit of this high-value Crop majority of the small tea growers have started cultivating black pepper as an intercrop and generating additional revenue per hectare area.

Cost of cultivation of the pepper as an intercrop is not much. Some of the common cultural operations such as weeding, irrigation, fertilizer application and others are commonly shared together which brings down the total cost of cultivation.

On the economic side, in a hectare of tea, there are about 80-85 shade trees. If pepper is planted on the shade trees and if one pepper vine yields about 1.5 kgs of dried pepper, farmers can get about 120 to 128 kgs of dry black pepper per hectare, substantially augmenting the income per hectare.

Climate change has tremendously affected the tea industry. The price of tea in the global and domestic markets fluctuates. Intercropping is one of the options that can protect this industry from vagaries of these market fluctuations.

Intercropping of black pepper in tea plantations leads to optimize utilization of horizontal and vertical space. Growing of pepper vines in live standards will also have an added advantage and contributes to protect the ecological environment. This can be viewed as soft measures for mitigating climate change as the surface area of a pepper vine (conical or cylindrical canopy with green foliage) will also help the environment.

Although, black pepper is common in this region but the production varies a lot from year to year. As most of the local pepper varieties are low yielding or have alternate fruit bearing characteristic, for long term sustainability of pepper in tea plantations choosing of proper variety pepper cultivars suitable for different climatic zones is very important and with better field management the total yield could be improved.

Some of APPL`s initiatives:

Manpower: In 2014, APPL has inducted 25 local educated youths and trained them to look after the pepper activities in the tea gardens. They are being called “Pepper Mitras” [An industry first]. Out of which 5 are ladies. They are working as ambassadors of pepper expansion in tea gardens as well as among the farmers.

Established 25 operational nurseries in tea gardens generating almost 5 lakh good quality pepper saplings.

Apart for doing business in tea, APPL is coming forward to create an enduring value for the N E region of India with a passionate endeavor for a science based and technology led approach that helps in building the capacity for the local farming community.

APPL is trying to give large scale back-end support like awareness camps, training, sourcing of good quality planting materials to the farmers of the N E region take up spices cultivation in their home stead farms and also give potential market channels.

Project on small farm integration for sustainable agriculture & improved access to the market

The project started its field level operations from 1 July 2015. To achieve the project goals and targets, APPL Foundation initiated activities by consulting with project stakeholders. The larger goals of the project are to improve the livelihood of 4275 farm households over the period of three years by promotion of turmeric and black pepper value chains. The project is being implemented in association with a trusted and proven field collaborator in the area by the name of Grameen Sahara.

The project is currently working in 32 villages in 6 clusters spread in Kamrup Metro, Kamrup Rural & Goalpara districts of Assam.

Already established 21 small pepper nurseries in the farmers level and are producing good quality pepper saplings.

Tea extension and Advisory services

The basic purpose of this initiative is to ensure that the small tea growers are trained in Good Tea Cultivation practices to increase yield and quality of green leaf which will help them get a fair price for sustainable livelihood and become a stable supply base. This department is also supporting tea growers in additional revenue generation through other initiatives like growing of black pepper in the shade trees and household arecanut trees to enhance their livelihood.

Already trained 1000 farmers in pepper cultivation in 40 clusters of Assam through this initiative.

Amalgamated Spice Park

A state of the art Spice Processing Plant was commissioned in Assam on 29th July 2015. However, this plant has been affected by continued manpower and technical challenges. Due to these challenges the Unit is not fully operational. To overcome these repeated issues, the facility has recently been technically reviewed by a team of experts to find an early solution. Despite these challenges, there is no denying the tremendous potential in the ready-to-use cooking ingredients market. We are making all efforts to capitalise on this potential.

Conclusion

Spices cultivation in the North East had a stunted growth as it remained under-exploited due to lack of system-specific production technologies, poor infrastructure and underdeveloped credit and extension facilities. The difficult terrains had retarded easy accessibility and reach from the rest of India. While stating that there is good potential for spice cultivation in N.E region, agro-climatic conditions pose a challenge to its maneuverability in the wake of climate change.

Generating a transformational impact will require new approaches, innovations, and increasing alignment and collaboration with the private sector and other stakeholders in the spice industry.

No one stakeholder, whether government, private sector or civil society, can do this alone, especially given newer realities including climate change and increasing pressure on land and water resources.

Instead, combining the competencies of diverse organizations and stakeholders and creating better alignment through partnership platforms can generate much greater impact. This can include leveraging of greater investments and on the ground resources, development of new innovative collaboration models that combine knowledge and resources of diverse stakeholders, and sharing of best practices, risks and mutual accountability for results.

The potential for North East to become the major spice producing region in the country is yet to be tapped to the fullest. With more focus, this land locked paradise can become a major spice producing hub in India.

Possibilities of saffron cultivation in North East India as alternative crop for doubling farmers' income

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Introduction

Introduction of low volume high value saffron crop with high B:C ratio in potential areas of North East states of India as an alternative crop will improve the livelihood security of resource poor farmers. Initial study of weather parameters has confirmed importance of 10 locations in 3 states that meet the minimum crop standards for saffron cultivation and thus can be planned for saffron introduction. Other states of North East that observe very high monsoon precipitation during summer can be thought of for saffron cultivation under atmospheric controlled protected structures through manipulation.

About Kashmiri saffron

Saffron is one of the prized and costliest spices in the world, botanically known as *Crocus sativus* Linn., belongs to family Iridaceae. Jammu and Kashmir state of India blessed with temperate climate is an unique state with distinction of producing quality saffron. A long history of saffron cultivation is revealed from historical records of Rajtarangni confirming its cultivation in Kashmir around 500 B.C. Primarily saffron cultivation was confined to heritage site of Pampore and in 1980'S saffron cultivation was further extended to new areas of District Budgam, Srinagar and Kishtwar and at present saffron in Jammu & Kashmir is cultivated in over more than 80 villages in over 3715 hectares with an overall saffron production of 17 M.T. About 17000 farm families are associated with this farming system directly or indirectly. At the time of saffron introduction in new areas farmers would take equal weight of Pampore soil and corms for sowing because saffron farmers had created a myth that saffron cultivation is possible only in Pampore soils. However new research efforts under National Saffron Mission has revealed possibility of cultivating saffron in J&K over 12407 hectares with new potential areas of 6700 hectares besides traditional saffron area of 5400 hectares (Salwee *et al*. 2017)- table 1. With present productivity level of 4.5 kg/ha future saffron production in Jammu & Kashmir is expected to rise to 55 M.T with an exchequer earning of Rs. 825 crores (127 million US Dollars).

Table 1. Potential Area under saffron cultivation in Jammu and Kashmir

Districts	Traditional area (ha)			New potential area (ha)	Total future area (ha)
	Area under cultivation	Fallow area	Total area		
Total Kashmir Division	3665	1922	5587	4500	10087
Total Jammu Division	50	70	120	2200	2320
Total J & K	3715	1992	5707	6700	12407

i) Plant

Saffron (*Crocus sativus* L.) is a perennial, herbaceous plant attaining a height of 45-50 cm. Corm foliar structure and floral organs constitute main parts of saffron plant (fig. 1).

Fig. 1. Saffron plant and its phenological stages

a) Corm

Saffron develops from corm which is a sub soil organ composed of parenchymatous tissues serving as base food material for inducing sprouting, flowering, foliage and daughter corms from September to May after surviving the period of summer dormancy. Mature corm measures 3-5 cm in diameter and is protected by fibrous leaf tunics. Apical, sub apical and auxillary buds are found in internodes. Apical and sub-apical buds are of mixed nature that develops vegetative and reproductive sprouts and leaf producing of auxiliary buds. The number of mixed mature buds increases with corm diameter up to 4 cm, beyond which the number of buds remain constant @2.6 to 2.8 buds/corm.

b) Foliar structure

After corm activation in September, the buds begin to protrude. Foliar structures begin to appear from 3-5 tubular tunics of white colour known as cataphylls. Cataphylls protect and strengthen stems in the process of appearance on the surface and protect the corms, once formed from dehydration and possible lesion 5-11 green leaves or monophylls between 1.5 and 2.5 mm wide are found per sprout and are called bristles and can measure up to 50 cm.

c) Floral organs

Saffron is an autumn flowering plant, producing light to deep purple coloured flowers. Saffron flowers emerge in the month of October-November from the bractea axils. Each flower consists of six violet coloured tepals, three inner and three outer ones, united in a long tube that starts at the top of the ovary. Each flower is borne on aerial shoots emerging from apical bud of mother corm of a comparatively large size and contains 6 perianth lobes, three inner and three outer ones, united in a long tube that starts at the top of the ovary, 3 stamens, 1 pistil having an inferior ovary and 3 brilliant orange red stigmas on a 3- branched long style. On an average, pistil length ranges from 5-6 cm with stigma measuring 2.5 to 3.0 cm (fig. 3).

ii) Biological cycle of saffron

Biological cycle of saffron is completed in following stages.

a) Corm dormancy phase-55 days(I[st] May to 25[th] June)
b) Flower ontogenesis phase-61 days (26[th] June to 25[th] August)
c) Bud sprouting phase-36 days (26[th] August to 30[th] September
d) Flowering phase -41 days(1[st] October to 10[th] November)
e) Vegetative phase- 142 days(11[th] November to 30[th] March)
f) Plant senescence-30 days (1[st] April to 30[th] April)

Kashmir saffron is famous for its intense yellow colour and distinct flavour that it imparts to the food items. Uniqueness of Kashmir Saffron is well known in the world for its intrinsic high quality. This uniqueness is attributed to its specific geographical identity and GXE Interaction. Historically Iran, India (Kashmir), Spain and Greece are the major saffron producing countries of the world. Distinct geographical difference exist between Kashmir and other saffron producing countries of the world particularly for altitude, latitude and longitude leading to different type of climates. Kashmir observes temperate type of climate compared to arid type in Iran, continental Mediterranean in Spain and humid sub-tropical climate in Greece. The geographical difference contribute to uniqueness of Kashmir saffron for quality and physical parameters for pistil (Nehvi & Salwee 2018). Besides pigments, pistil an economic product is rich source of carbohydrates, calcium, sodium, iron, fructose and sorbital -tables 2&3 (Iffat Hassan *et al*. 2015).

Table 2. Saffron flower composition (range in g/100 g on dry weight basis: photometric absorption

Flower part	Ash	Protein	Lipids	Carbohydrates	Reducing Sugars
Tepal	6-6.2	8-8.2	1.9-2.1	59-68.9	3.5.9.45
Stamen	10.9-11.6	23.9-24.1	10.6-10.8	33.33.8	4.0-4.5
Style	8-8.6	11.4-11.8	3.2-3.7	68-71.2	14.2-16.2
Pistil	6.5-7	13.5-13.8	8.5-8.6	62.2-62.3	15.9-16.9

Table 3. Mineral composition (range in g/100 g on dry weight basis)

Minerals	Tepals	Stamens	Style	Stigma
P	0.21-0.24	0.57-0.59	0.29.0.30	0.33
Mg	0.09-0.10	0.30-0.31	0.18	0.13-0.14
Ca	0.12-0.13	0.21-0.22	0.34-0.35	0.10-0.11
Fe	0.02-0.03	0.02-0.03	0.04	0.01
K	1.31-1.37	3.75-3.80	1.79-1.83	1.47-1.49
Na	0.01	0.01	0.01-0.02	0.01
Glucose	11.10-11.18	5.70.5.75	8.10-8.30	7.35-7.45
Fructose	0.40-0.61	1.30.1.38	0.50-0.08	0.35-0.43
Sucrose	0.18-0.25	--	--	---
Maltose	0.11-0.16	--	0.05-0.08	---
Inositol	0.23-0.29	0.69.0.76	--	0.34-0.39
Sorbitol	--	0.10-0.13	--	0.23-0.26
Mannitol	0.71.0.79	--	--	---

iii) Uses of saffron

a) Saffron as medicine

Saffron merits usage as a medicinal herbolary from ancient times. Saffron is composed of three chemicals; bright yellow colouring carotenoid pigment, a bitter taste picrocrocin and a spicy aroma saffranal with carotenoid attributing it an anticancer, antitumour effect and immunomodulatory properties. Saffron finds many uses in Ayurveda, Unani, Chinese and Tibetan medicines. It is popularly known as a stimulant, warm and dry in action helping in urinary, digestive and uterine troubles.

In Ayurveda, saffron is used to cure chronic diseases like asthma, arthritis, for treating cough and cold, acne and to regulate menstrual disorders. It is also used in fevers and enlargement of spleen and liver. Saffron had been found to be beneficial in the treatment of several digestive disorders, strengthening the function of stomach, antispasmodic, diaphoretic, a sedative which combats cough and bronchitis, mitigates colic and insomnia. An antioxidant property of saffron cannot be ruled out.

Aqueous and ethanol extracts of saffron have been found to reduce blood pressure in dose dependent manner. The potential of saffron extract and its active carotenoid ingredients for treatment of neurodegenerative disorders accompanying memory impairments, psoriasis, and allergic asthma and as antidepressant, anti-inflammatory as well as anti-seizure remedy cannot be ruled out. The Iranians use saffron as an anticonvulsant remedy. Some data also suggest that crocetin may be helpful in preventing Parkinsonism. Recent research has suggested suppression of LDL oxidation by crocetin contributes to attenuation of *atherosclerosis*. Saffron is also rich in many vital vitamins including vit A, folic acid, riboflavin, niacin and vit C that are essential for optimum health.

b) Saffron as spice

Saffron is a regal spice of matchless aroma and is the costliest in the world. 1,60,000 flowers are needed to make one kilogram of pure saffron. Each filament can colour 700 times its own weight in water. The "golden spice" as it is known finds its use as a colouring and flavouring agent. It has a distinct aroma and flavour because of the chemical component safranal and picrocrocin. Because of the presence of natural carotenoid chemical compound crocin, it imparts yellow colour. It is used in soups, sauces especially in rice dishes to give bright yellow colour and distinctive flavour. In Middle East, it is extensively used in rice, coffee and desserts.

Saffron tea is also becoming popular. In Spain, where saffron is also cultivated, it is used for making typical Spanish cusines. In Kashmir saffron is used in preparing "zaffrani kehwa" and is also used as a colouring agent in Kashmiri wazwan. Not only this, saffron is also used in dairy for coloring butter and cheese, used as a key ingredient in the manufacture of flavoured chewing tobacco. Since saffron is a natural organic colourant and unlike other plant colourants it is highly permanent and does not fade easily hence finds its use as a dye. Also saffron finds its use in cosmetic industry as an ingredient for making face marks to remove pimples, to soothe rashes as an antiallergenic. It is also use in beauty soaps. The dried stigmas are used for making perfume.

c) Saffron in perfumes

Owing to its health properties as a relaxant and natural cure against headaches, in the Middle East, saffron is used to prepare an oil based perfume called "Zaafran Attar" which is a blend of saffron and sandal wood. Saffron is also used as a perfume ingredient in many famous internationally renowned brands In dairy industry.

Saffron gives a lovely colour to butter and cheese. It also enhances the taste and provides many health benefits. It is also used in saffron ice cream. Saffron is used as a key ingredient in the manufacture of flavoured chewing tobbaco (Zaafrani Zarda) mainly used in India. Saffron enhances the taste to a great extent.

d) Food industry

Saffron is used in the food industry as one of the ingredients in dehydrated food stuff, mixes, soups, masalas, ice cream and many other processed food products. Using modern industrial food systems, products such as, saffron dessert powder, saffron crème caramel powder, saffron beverage powder, saffron cake mix, saffron cream powder, saffron batter powder, saffron soups and ready to use saffron spice mixtures for a variety of uses have been produced and offered to consumers.

e) Saffron in rituals

Before the Renaissance, saffron had several religious uses. Even today, Indian women, when offering prayers, receive a paste of saffron on their foreheads (Tikka) as a symbol of blessings, good luck and benevolence. Also in India, saffron is offered as a sacrifice in many temples. Certain holy texts have been known to be written with saffron ink.

f) Saffron in cosmetics

In Asian countries, where the yellow colour produced by soaking saffron filaments in liquid was called “the very perfection of beauty”, saffron became the most valuable cosmetic that could be obtained. The use of saffron as a face mask to remove pimples and soothe rashes was in the olden days limited to royal women or women from the houses of wealthy aristocrats or merchants. These ladies used it for a variety of purposes. Saffron is antiallergenic and a paste made from saffron, applied on the face and exposed parts of the body was used in the same way as foundation makeup is used by women today.

Not only did this saffron paste impart smoothness to a woman’s skin, it also gave the skin a golden tint, which was thought to be so desirable that pregnant women even drank saffron infused in milk in the hopes that their unborn infants would acquire golden complexions. Saffron extract is also used in beauty soaps. Traditionally Indian brides use it for ceremonial painting of their skins. The use of saffron in the cosmetic industry is now fairly widespread with the trend to use natural products and owing to its active substances. Safinter is the leading supplier of saffron to the cosmetic industry. Hossein-Fekrat (2004) demonstrated the application of saffron extracts from dried saffron stigmas by aqueous ethanol in formulations of cosmetics, skin cares and sun protection products. Its dried stigma is used in dyes and perfumes.

iv) Economic benefits of saffron farming

Under high density production system, saffron growers after investing Rs 19,86,368 over a period of 4 years on different input variables like corms (Rs 10,94,400), energy (Rs 25,000), nutrients/protectants (Rs 2,56,968) and labour (Rs 6,10,000) achieve returns to the tune of Rs 1,05,03,000 on account of sale of 47.52 kg of saffron over a period of 4 years (71,28,000) and sale of 250 quintals of saffron corms in the 4th year (Rs 33,75,000). However, under normal density production system after investing Rs 9,28,560 on saffron farming system, the farmers attain returns to the tune of Rs 46,35,000 on account of sale of 25.5 kg saffron amounting to Rs 38,25,000 and Rs 8,10,000 from the sale of 60 quintals of graded saffron corms. The estimated sale price of saffron and corms presumed to be Rs 1.50 lakhs/kg and Rs 13,500/quintal respectively. Under high density plantation a benefit of Rs 85,16,632 is achieved with a B:C ratio of 4.28:1 whereas a benefit of Rs 37,06,440 is obtained under normal density production system with a B:C ratio of 3.99:1 (Nehvi *et al*. 2017)-table 4. Average productivity of 11.88 kg/ha achieved under high density plantation compared to 6.37 kg/ha achieved under normal density over four years plant cycle will boost overall production of state. In comparison to saffron, cereal based cropping system fetches low benefit of Rs 128000 to Rs 108000/hectare pooled over 4 years whereas Rs 1600000/ha over 4 years is achieved from horticulture farming system.

Table 4. Benefit cost analysis of high density production system module vis-a-vis normal density-pooled over 4 years planting cycle

Planting system	Input cost (Rs)	Returns (Rs)	Benefit (Rs)	B:C Ratio
Saffron under normal density	928560	4635000	3706440	3.99:1
Saffron under high density	1986368	10503000	8516632	4.28:1
Maize alone	-	-	128000	-
Wheat alone	-	-	108000	-
Orchard (juvenile) alone	-	-	1600000	-

Possibilities of saffron cultivation in North East India for doubling farmers income

The economy of North East India comprising of eight states *viz*., Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is agrarian. Little land is available for settled agriculture. Along with settled agriculture, *jhum* (slash-and-burn) cultivation is still practised by a few indigenous groups of people. The inaccessible terrain and internal disturbances has made rapid industrialisation difficult in the region. Local vegetables in Assam, terrace farming in Nagaland, oil palm plantation in Mizoram, paddy fields in Manipur and tea gardens in Darrang, Assam comprise agricultural of North East India (officially called North Eastern Region, NER). Before deciding possibilities of introducing saffron cultivation in suitable regions of North East India for doubling farmers income following crop requirements need to be taken in to consideration:

1) Localities at an altitude range from 1500 to 2400 m. a.m.s.l covered with snow during winter with sub zero minimum temperatures during December to February to provide necessary chilling of 1100 hrs for commercial cultivation of saffron.
2) Moderate maximum temperatures of 17-20^{o}c during October & November associated with sunny days during the flowering period is favorable for good yield
3) Saffron is sensitive to water & needs little water from August till November to facilitate uniform flowering and vegetative growth with a total requirement of 2789 m^3 /ha
4) Dry period during dormancy period (May to July) with natural precipitation of around 100-150 mm is critical to avoid corm rotting.

Weather parameters and elevation of 10 places from 3 states of North East India confirm to the possibilities of saffron introduction (table 5). Locations are blessed with minimum crop standards with respect to temperature and moisture requirements.

Table 5. Possible location of North East for saffron introduction

State	Identified locations
Arunachal Pradesh	Tawang, Bomdilla, Mechuka Valley, Mayodia
Skkim	The Tsomho Lake, Nathu La Pass, Gangtok, Katao
Assam	Dargelling, Lava

Other major states do not confirm to saffron cultivation primarily because of high monsoon precipitation ranging from 1400-1600 mm received during summer (May-July). Excess water accompanied with high humidity will lead to saffron corm rot caused by *Fusarium species* thus would lead to failure of crop. Such places confirm to commercial cultivation of saffron indoor using high tech atmospheric controlled protected structures for which protocols are available. Saffron corms are programmed under different regimes of temperature to undergo various phenological stages like flower ontogenesis, shoot elongation and anthesis. Programmed saffron corms after flowering has to be planted in open in potential new North East areas for corm production for second cycle of flower production.

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SESSION II:
CROP IMPROVEMENT AND BIOTECHNOLOGY

LEAD LECTURES

Conventional and genomics approaches in improvement of spices

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Spices are high value and low volume, export oriented commodities, which yield aromatic and pungent principles commonly used for flavouring and seasoning of food and beverages. Spices also constitute a major portion of medicinal plant wealth of India and are widely used in indigenous medicines. India is the centre of origin and diversity for major spices like black pepper and cardamom and possibly for ginger and turmeric. Many spices typically have long breeding cycles, and development and introduction of improved cultivars by plant breeders may require many breeding cycles and dozens of years. Like other sectors of horticulture, the spices also face highly dynamic situations arising from such factors as decreasing labor availability, increasing environmental concerns, cost of energy, climate change and epidemics of new and invasive insects and diseases. The generally reactive nature of response to these factors translates to the release of new varieties only after such pressures have accumulated significant impact on production. A general overview of spices genetic resources, pre-breeding, precision breeding, and genomics approaches and achievements are presented here.

Plant genetic resources of spices

While spices such as black pepper and cardamom originated in India, it is also a major production centre of many other spices like ginger, turmeric, chillies, vanilla and tree spices (nutmeg, cinnamon, clove and garcinia). Cultivar and species diversity are the principal components of diversity of spices (Sasikumar *et al.* 1999a; Krishnamoorthy *et al.* 1997; Prasath & Venugopal 2004). Collection and conservation of genetic resources of spices are regarded as being highly important in India. In addition to the activities of the ICAR-Indian Institute of Spices Research (IISR) in Kerala, collections of spices germplasm are also maintained at various research centers under the All India Coordinated Research Project on Spices (AICRPS). Presently, 9186 germplasm accessions of major spices are being maintained in field gene banks. A schematic representation of germplasm collection and conservation activities of spices is represented in Fig. 1.

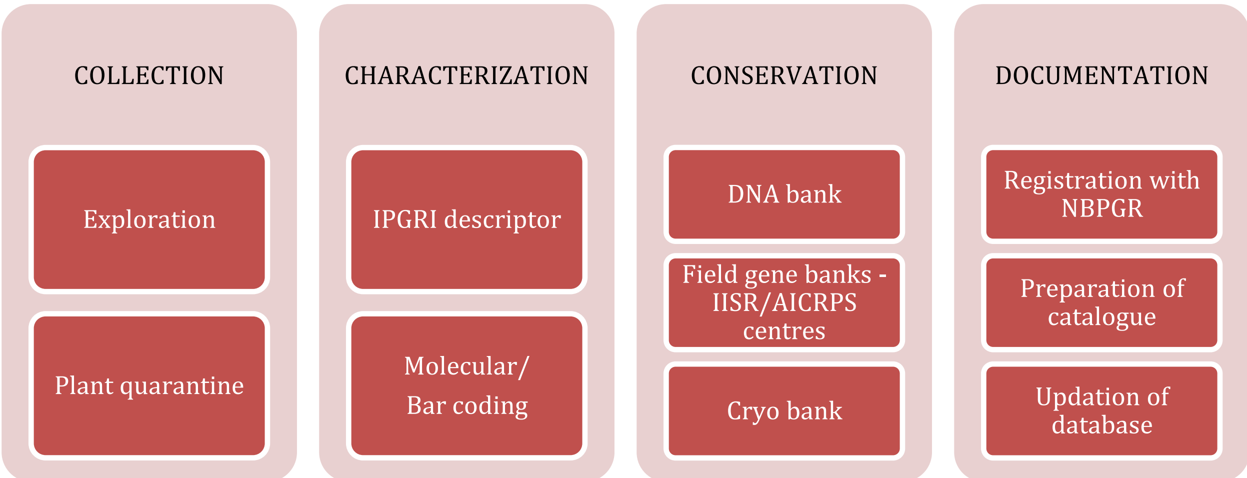

Fig. 1. Schematic representation of germplasm collection and conservation activities of spices

The collected accessions are conserved in the *ex situ* gene banks as well as *in vitro* (medium term and long term) repositories (Nirmal Babu *et al.* 2004). Systematic characterization of the germplasm is being undertaken to locate useful genes in the primary or secondary gene pools for biotic and abiotic stresses, yield as well as quality and such gene sources are being incorporated in the pre breeding programme (Sasikumar *et al.* 1999a; Sasikumar 2005). The unique accessions are also registered with the National Bureau of Plant Genetic Resources (NBPGR) New Delhi. IPGRI descriptors are published for characterization of black pepper and cardamom. Molecular markers such as SSR, ISSR and RAPD are developed for germplasm characterization of turmeric, ginger, black pepper and cardamom (Siju *et al.* 2010; Jaleel & Sasikumar 2010; Johnson George *et al.* 2006).

A core collection of germplasm of the mandate crops is being identified using the morphological and/or molecular traits. The germplasm collection is being enriched constantly by addition of fresh collections from within the country or introductions based on germplasm explorations/exchange. Towards documenting and accessing the plant genetic resources of spices, genetic resources data base namely 'Spice Genes', an information service for the research community with the aim to collate information on the origins, characteristics and availability of various spices germplasm is developed at ICAR-IISR.

Precision breeding in spices

The research efforts so far resulted in release of 72 improved varieties of spices (AICRPS 2017). The conventional and/or biotechnological methods have been employed in evolving the high yielding varieties of spices (fig. 2). Varieties tolerant to biotic stresses (table 1), abiotic stresses (table 2) and varieties with high quality attributes (table 3) are available in spices.

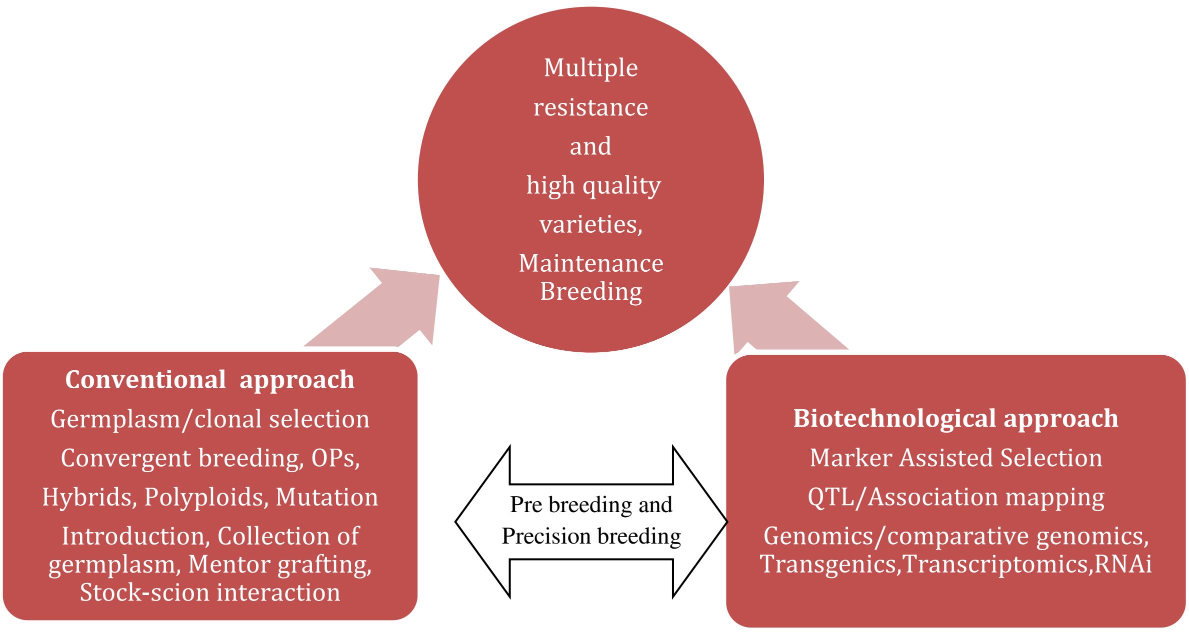

Fig. 2. Schematic representation of breeding approaches in spices

Table 1. Spices varieties tolerant to different biotic stresses

Crop	Biotic stress	Variety
Black pepper	Tolerant to root knot nematode	Pournami
	Tolerant to foot rot diseases/ Phytophthora foot rot	IISR Thevam & IISR Shakthi
Small cardamom	Tolerant to rhizome rot	IISR Avinash
	Resistant to *Katte* diseases	IISR Vijetha & Appangala 2
	Tolerant to stem borer and thrips	PV 2
	Tolerant to azhukal disease	ICRI 2
	Tolerant to rhizome rot	ICRI 3
Turmeric	Resistant to rhizome rot	Suguna, Sudarshana, Pant Peetabh
	Resistant to nematodes	IISR Pragati
	Resistant to scale insects	BSR 2
	Resistant to leaf blotch	IISR Kedaram
Ginger	Resistant to root knot nematode	IISR Mahima
	Tolerant to soft rot and bacterial wilt disease	Athira, Karthika

Table 2. Spices varieties tolerant to different abiotic stresses

Crop	Abiotic stress	Variety
Black pepper	Shade tolerant	Panniyur-2
	Suitability to high elevations	IISR Girimunda, IISR Malabar Excel
	Wider adaptability	Sreekara, Subhakara, Panniyur 7
Small cardamom	Drought tolerant	ICRI 5
	Early maturing	PV 1, ICRI 1
Turmeric	Tolerance to Salinity	Narendra Haldi 98
	Drought prone areas	Co 1, BSR 1
Ginger	Wide adaptability	IISR Varada, Suprabha

Table 3. Spices varieties released with high quality attributes

Crop	Quality attribute	Variety
Black pepper	High oil and oleoresin	Sreekara, Subhakara, Pallode-2
	High piperine	Panniyur-2, IISR Malabar Excel
	High dry recovery	IISR Shakthi
Small cardamom	High oil	PV 2, Mudigere 1, ICRI 1, Appangala 1
	High 1,8 cineole	ICRI 3, Appangala 2
	High dry recovery	PV 2
Turmeric	High curcumin	IISR Prathiba, IISR Pragati, Megha Turmeric
	Essential oil	Sudarshana, Suvarna
	High dry recovery	Roma, Suroma
Ginger	Essential oil	Himgiri, Aswathy

Pre breeding

Pre-breeding refers to all activities designed to identify desirable characteristics and/or genes from unadapted materials that cannot be used directly in breeding populations and to transfer these traits to an intermediate set of materials that breeders can use further in producing new varieties for farmers. It is a necessary first step in the use of diversity arising from wild relatives and other unimproved materials. The most significant pre breeding efforts at the institutes are summarized in table 4.

Table 4. Pre breeding achievements of spices

Achievement	Reference
Interspecific hybrids in *Piper* to confer *Phytophthora* resistance to confer *pollu* beetle resistance	 Vanaja *et al.* (2007) Sasikumar *et al.* (1999b)
Interspecific hybrid in vanilla to impart disease resistance	Divakaran *et al.* (2006)
Polypoidy in black pepper	Nair & Ravindran (1992)
Genomics and transcriptomics approaches to identify and isolate candidate genes for foot rot resistance in black pepper; bacterial wilt resistance in ginger	 Neema & Johnson (2017) Prasath *et al.* (2014)
Mutation breeding of ginger to induce rhizome rot resistance	Prasath *et al.* (2015)

Black pepper

In black pepper, a vegetatively propagated perennial, the major bottleneck is damage caused by fungus *Phytophthora capsici*, nematode *Radopholus similis* and the pest pollu beetle (*Longitarsus nigripennis*). The genetic resources of this crop in India are a great strength. This germplasm, containing local cultivars, wild forms collected from the area of origin and related species are a wealth to be utilized for crop improvement. Cultivar diversity is one of the principal components of diversity in black pepper and over 100 black pepper cultivars are established in India. The main breeding objectives are high yield, with resistance to *Phytophthora* and drought, coupled with good quality parameters. Conventionally, clonal selection is the main breeding method. Research efforts have been focused on hybridization and polyploid breeding and micropropagation. The most promising approach for bringing these characters into a single genotype is gene pyramiding through conventional and biotechnological methods. Now molecular approaches are used to develop input-responsive varieties with biotic and abiotic resistance for higher yield and quality.

Ginger

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. Sexual reproduction is not reported in ginger, however the 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.

Lack of seed set is a major handicap in sexual recombination. Hence, crop improvement work is concentrated purely on selection of clones. However, a few reported success are available on use of polyploidy and mutation. The major crop improvement objectives in ginger are high yield, wide adaptability, resistance to diseases (such as rhizome rot, bacterial wilt, and Fusarium yellows), improvement in quality parameters (oil, oleoresin), and low fiber. Crop-improvement work in ginger is constrained due to the absence of seed set. As a result, clonal selection, mutation breeding, and induction of polyploidy are the crop improvement methods employed.

Ginger is intimately associated with the food habits of India, China, Vietnam, Thailand, Japan, and other Southeast Asian countries, and hence it is all the more important to develop newer cultivars with improved nutritional values, cultivars that are resistant to pathogens and insect pests. Production of pathogen free seed rhizome by microrhizome technology can be capitalized to ensure healthy crop. Though variability has been created by exploiting polyploidy, its potential to increase the productivity is yet to be realized. Biotechnology and new found knowledge in plant genomics can be exploited for generating variability which would result in development of resistant cultivar. The attempt to induce seed set in the natural population is yet to yield significant results. These sporadic research attempts need to be consolidated and focused to manipulate ginger genetically.

Turmeric

Existence of wide variability among existing cultivars with respect to growth parameters, yield attributes, resistance to biotic and abiotic stresses, and quality characters has been reported. A wide variation in chemical composition of turmeric is also observed across genotypes and agroclimatic conditions.

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

Deeper understanding of curcumin's therapeutic potential will help to place this fascinating molecule at the forefront of novel therapeutics. Heterosis breeding in turmeric is an unexploited area and has great potential which needs to be harnessed in order to develop high yielding, high curcumin varieties. Plant genomics can be exploited for development of potential new cultivars with improved yields and curcumin concentration.

Biotechnological approaches

Various biotechnological approaches have great significance in conservation, utilization and increasing the production and productivity of spices. Protocols for micropropagation and commercial production of disease free planting materials are available for many spices. Efficient plant regeneration protocols are also available for exploiting somaclonal variation especially in crops like ginger, turmeric and vanilla where the available natural variability is relatively low. Synseed and micro-rhizome technology is also available for many spices for propagation, conservation, movement, and exchange of germplasm. *In vitro* and cryo preservation technologies for conservation of spices germplasm are available for many spices and *in vitro* gene banks for spices functions at ICAR-Indian institute of Spices Research. Molecular markers were used for crop profiling, finger printing, molecular taxonomy, identification of duplicates, hybrids, estimation of genetic fidelity of micropropagated and *in vitro* conserved plants in many spices. Molecular maps are developed in capsicum and the development of molecular maps are in progress in other spices for marker aided breeding and selection.

Genomics

Advances in DNA sequencing technology during the last decade have dramatically impacted genome sequencing analysis. Whole genome sequencing and transcriptome analysis using Next Generation Sequencing (NGS) technology is one of the most popular tools, and it has been applied recently to several non-model species that lack genomic sequence information. The primary goals of transcriptome analysis in spices are, to understand how changes in transcript abundance control growth and development and plant-pathogen interactions of an organism and its response to the environment.

Despite these challenges, ultra high-throughput sequencing based transcriptomics approaches promise 'never-before' opportunities to explore plant transcriptomes. As improvements to the sequencing chemistry, sequencing hardware and software and statistical methods of analysis continue to progress, the expectations for transcriptomics studies will continue to increase. The NGS based transcriptome approaches have clearly demonstrated their advantages over previously developed methods and are becoming the new standard for transcriptomics studies in spices.

Genome-wide selection

Among the most rapidly developing approaches is genome-wide selection (GWS). GWS makes use of genomic estimated breeding values (GEBVs) as selection parameters, rather than the estimated breeding values (EBVs) traditionally used by fruit breeders. GEBVs are derived for individuals in a phenotyped training population using dense genome-wide single-nucleotide polymorphism (SNP) markers, to establish marker effects on complex phenotypes controlled by a large number of genetic loci. Individuals in breeders' selection populations are then screened and GEBVs of individuals calculated based on genetic marker information, in order to identify outstanding 'elite' individuals (fig. 3). These may then be used to advance generations, or evaluated in the field as potential cultivars.

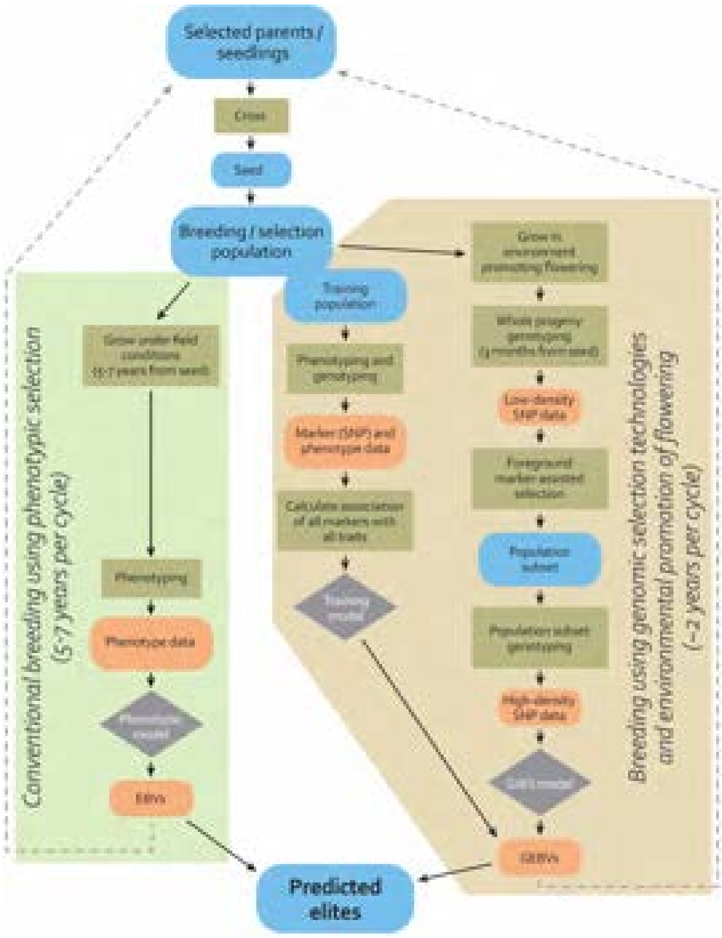

Fig. 3. Comparison of breeding parameters between standard breeding using phenotypic selection in the field, and genomics-assisted breeding where progeny are raised in conditions that promote flowering, and foreground marker assisted selection (MAS) is applied for major gene 'must-have' traits, followed by genome wide selection (GWS) for traits controlled by multiple loci (Nocker & Gardiner 2014)

The registration of Farmers' Varieties through *PPV & FRA*

The registration of Farmers' Varieties is an unique provision in the Protection of Plant Varieties and Farmers' Rights Act (PPV & FR Act 2001) and IISR as nodal centre for DUS (Distinctness, Uniformity and Stability) testing in major spices have helped farmers in registering their varieties. As on date, three certificates were issued to the farmers for their black pepper varieties and five in Small cardamom by PPV & FRA. Among the high yielding varieties registered by the black pepper cultivators, 'Pepper Thekkan', is distinct for its multi-branching habit of spikes, 'Agali Pepper' characterized for its high dry recovery and 'Kumbuckal Selection' for its drought tolerance. The high yielding small cardamom varieties registered by the cultivators are from the district of Idukki in Kerala.

The registration of 'Farmers' Varieties facilitate the farmers to register those varieties cultivated and evolved or bred by them, wild relatives or land races about which the farmers possess common knowledge. These varieties are considered as extant varieties and shall be registered if it conforms to distinctiveness, uniformity and stability. Once a variety is registered, farmers obtain the exclusive right to propagate and market it. This right recognizes the role of farmers as plant breeders and innovators.

Areas of focus for the future breeding programmes

- Establishing global gene bank of spices
- Black pepper breeding for multiple resistance by convergent breeding
- Association mapping in black pepper
- Identification of genotype specific molecular markers in spices
- Isolation and characterization of resistant genes through transcriptome approach (*Phytophthora* – black pepper, *Ralstonia/Pythium* – ginger)
- Soft rot resistant ginger and ginger (fresh) with long shelf life
- Ginger varieties suitable for secondary agriculture
- Hybrid turmeric
- Turmeric genotypes with better curcuminoid profile and high yield
- Low input responsive spices varieties (organic plant breeding)
- Hermaphrodite nutmeg
- DNA bar coding for phylogenetic studies

Conclusion

Plant genetic resources collection, conservation, cataloguing and evaluation of spices; precision breeding for higher yield, better quality and tolerance to diseases; prebreeding to develop noble breeding lines as well as concentrated efforts to popularize the released varieties among all the stakeholders have yielded significant dividends in the arena of spices research. Both conventional and biotechnological approaches have been used in evolving the improved varieties. The agenda set forth, in tune with the needs and leads, for the coming years are destined to turn a new leaf in spices research in the days to come.

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Breeding better seed spice varieties

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The fact is the earth is warming. This is seen in the change of seasons, shortening of the cool period and also reduced and/ or shift of monsoon pattern. Such changes have considerable impact on the cultivation of crops and the agricultural output as a whole. This is no myth but a reality which we are facing now. We can't rely on the weather. It can change any time and as our past experience indicates, most damage is caused towards the end of the season when the grain formation is either going on or crop has almost matured, when unseasonal rains have created havoc to the extent that in some cases a hundred percent washout was noted. Over the years the climate has become more unpredictable, with the global warming increasing day by day, climatologists are puzzled as they are and warn of bitter times ahead. Are we prepared?

In an earlier article on a similar topic, I dealt with the effect of global warming on agriculture and vis-à-vis its effect on spices cultivation (Sastry 2015), the gist of which is given here for general reference.

Climate change is the most important global environmental challenge facing humanity with implications for natural ecosystems, agriculture and health (Parikh & Parikh 2002; Senapati 2009). The perusal of general circulation models (GCM s) on climate change indicate that rising levels of greenhouse gases (GHGs) are likely to increase the global average surface temperature by 1.5-4.5°C over the next 100 years. The difference of average temperature between the last ice age and present climate is 6°C. This will raise sea-levels, shift climate zones pole ward, decrease soil moisture and storms. Global warming is predicted to affect agricultural production (Senapati *et al.* 2013).

Let us look at the changes in the monsoon pattern in our country. An interesting account on comparison of monsoon pattern over decades is given by Guhathakurta *et al.* (2015). Based on the available data, they divided the whole country into four different zones. Among the zones, variations in the trends of the monsoon over several decades was noted. In some regions like in peninsular India, the monsoon was stable over the decades, in the north west and north east India, changes in the trend was noted.

What other parameters to consider?

While global warming and the related seasonal changes are real, the spices as a group are also experiencing differing demands from the consumers. The consumer is more urban oriented, upward mobile hence has become more quality and health conscious. Spices being a high value – low volume crops are feeling this increased and shifted demand perspectives. Seed spices are no exception. If we closely observe, for a breeder the present-day goals can be listed as given below.

1. Threat of global warming and shifting seasonal pattern
2. Organic farming
3. Specialty varieties – varieties with better quality parameters including the extractable chemical constituents.
4. Urban agriculture

To achieve these goals a paradigm shift is needed in seed spices breeding. Unfortunately, the seed spice crop improvement is still dependent on selections, with occasional combination breeding. As of now in India, the orientation is to develop high seed yielding varieties, though in recent years quality aspects are also given priority. The quality aspect still looked at is only essential oil content.

Weather based varieties

Ideally seed spices are cool season crops. Yet they can't tolerate frost. Any abrupt change in climate is also not tolerated. The major cultivated areas of seed spices in India is depicted in (Fig. 1). Cumin is one good example. We all know the ill effects of even 2 to 3 days cloudy weather when it gets affected by the blight. Hence, while cool period during growth and slightly warm to warm conditions are needed for the seed setting and maturity. Abrupt increase in temperature during the seed maturation will bring in forced maturity and the quality of the produce is reduced. Crops like coriander and fenugreek are cultivated across the country for various end uses. In such conditions, it would be ideal to divide the country into different zones suitable for the cultivation of the seed spices so that oriented breeding for local adaptability may be brought in. such kind of zonalization may also help in combating the diseases better.

The deployment of varieties based on zonalization is a routine practice in wheat (Doodson 1979; Singh 2005; Chahal & Gosal 2002). For the seed spices, we may have three divisions- a) cool all through the season, b) cool season though the environment is warmer towards the harvest period c) warm all through the season. The wheat growing zones as presented in fig. 2 may be considered to start with and varieties may be developed accordingly. We may consider coriander as an example. The coriander grown in peninsular India faces warm climate. In such situations we require varieties which have shorter growing time. The coriander grown in Northern Hills Zone has a longer cool period. This also suggests that AICRP on Spices will have to create different CVTs and IVTs for different zones than having just one as is presently done. This will also help in generation of varieties for the respective zones. Existence of different plant types in coriander and their characteristics based on ideotype concept has earlier been discussed by Sastry *et al.* (2016) and Sastry (2015).

Fig. 1. Major seed spices growing regions in the country (the outer enclosed area represents the general spread of seed spices, while the inner enclosed area indicates intensive cultivation of seed spices.

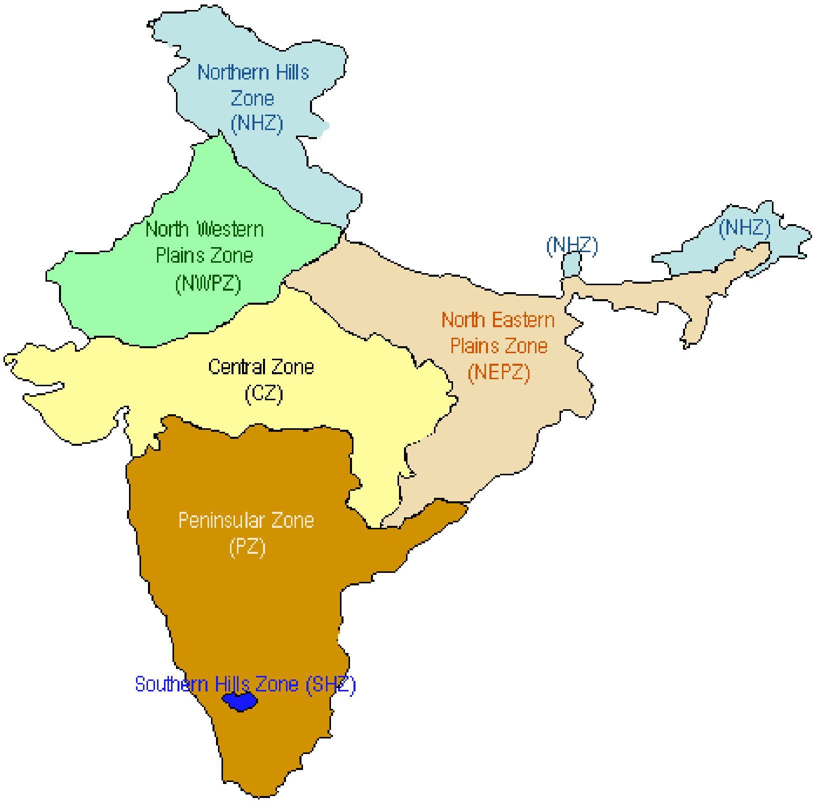

Fig. 2. Wheat growing zones in India (downloaded from http://www.krishisewa.com/agroclimatic-zones/wheat-growing-zones.html).

Specialty varieties

Quality is important in spices. The end uses of spices also vary, hence it would be ideal to breed varieties with specialty characters. This is still a far cry but needs consideration. The quality of spices is based on the aromatic principles. What if we can breed varieties which have these aromatic principles in higher quantities. This can be possible if we know the entire biosynthetic pathway of a given quality compound. As of now the knowledge is still limited. Canula in rapeseed mustard is fine example where the erucic acid content has been brought to near zero through modification of the fatty acid biosynthetic pathway. With the developments in biotechnology this should not be a difficult task in times to come.

Urban agriculture

In seed spices like coriander, fenugreek and to some extent dill leaves and young plants are also used for culinary purposes. As a matter of fact coriander is cultivated around urban areas prompting the cultivation of coriander and fenugreek all through the year in either field or green house conditions. This requires breeding varieties which have high biomass production during early stages of crop. In many areas, it is also common to have atleast 2-3 cuttings of leaves before the crop is left to produce seeds. As can be visualized, general varieties may not prove to be ideal in such conditions. Efforts in this direction are already in vogue (RCr 728 developed by S K N College of Agriculture, Jobner).

Organic farming

Organic farming is a holistic method where both crop management and crop protection measures along with the methods by which specific varieties developed matter. An account of the research done on organic management of seed spices is presented by Sastry *et al.* (2008). As part of technology development, efforts have also been made to develop bioformulations which enhance crop growth and tolerance to diseases and pests (Shivran *et al.* 2012).

In the conventional breeding major emphasis has been placed on generating varieties which are fertilizer responsive, show resistance to various biotic and abiotic stresses and may be better in certain quality. However, when generating genotypes for the organic agriculture emphasis will have to shift from the conventional approach (Rao 2005) has dealt with this aspect brilliantly in his article. Organic farming need varieties that are more efficient in nutrient utilization, in other words this system needs varieties that give optimum yield levels at low fertility levels, are highly competitive and vigorous in growth as in organic farming system, the weeds compete and grow well with crop plants and at the same have high degree of resistance to diseases and pests besides the stability of itself (Bueren & Edith 2002).

The conclusions drawn by Ceccarelli *et al.* (2000) have an important bearing on programming of breeding for organic agriculture,

- Instead of selecting for broad (or universal) adaptation, plant breeding must target the interactions between genotype and environment (GxE).
- The selection work has to be carried out in the target environment.
- It is important to make better use of locally adapted germplasm.
- The participation of farmers in the selection process is crucial in order to benefit from their huge knowledge of local varieties, appropriate production techniques and crop-environment interactions.

Naturally then, the varieties that have been specifically bred for the intensive agriculture may not perform well under the organic agriculture. Since the organic produce is supposed to be wholly organic, Several techniques would be banned from the development of 'organic varieties': with immediate effect, genetic engineering, cytoplasm male sterile hybrids without restorer genes, protoplast fusion, radiated mentor pollen and induced mutations; then possibly in the future, embryo culture, ovary culture and *in-vitro* pollination. 'Organic breeding' programmes will need to be certified, in order to guarantee that only allowed techniques are used. In some interpretation the exchange of plant material between 'organic breeding' programmes and other breeding programmes would not be allowed. According to the guidelines developed by Bueren & Edith (2002), the guiding principle of organic breeding would be to enhance the potential of organic farming and biodiversity. Organic plant breeding should be a holistic approach that respects natural crossing barriers and be based on fertile plants that can establish a viable relationship with the living soil.

Organic farming guidelines strictly limit the breeding methods that can be used for breeding of the varieties. Luckily in seed spices, the methods used for crop improvement are still the traditional plant breeding methods, hence presently available varieties can be safely prescribed for organic farming. One of the limiting factors in seed spices is their slow germination and poor stand establishment. As a result, seed spices are less competitive in comparison to weeds. As organic farming prohibits synthetic weedicides, it is essential to increase the competitive ability in crop plants. Further, with the limitation of use of synthetic pesticides and fungicides, control of plant diseases and pests may prove a challenge even though effective organic pesticide are available. Thus, need for development of resistant varieties is emphasized. This also needs altering the ideotype so that suitable varieties for organic cultivation can be developed (Sastry 2015).

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Opportunities for tree spices production in NER

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Introduction

There are14 tree spices, commonly grown in India. Most of them occur naturally in humid tropical forests of South and South East Asia, Pacific Islands and Tropical America. Among them clove, nutmeg, cinnamon, tamarind, garcinia, kokum, curry leaf and allspice are economically the more important ones. Various plant parts of these trees are used as spices: bark and leaves (cinnamon), flower bud (clove), aril or mace and seed (nutmeg), leaves and fruits (allspice), leaves (curry leaf), and fruit (tamarind, garcinia and kokum). The main commercial products of these crops are whole spice, ground spice, spice oil and oleoresin.

Cinnamon, clove, nutmeg and allspice were introduced to India by British during the eighteenth century. Cinnamon is cultivated in Kerala, Karnataka and Tamil Nadu and is more prevalent in the hilly regions of Western Ghats. The crop is also grown in the kitchen gardens of NER.

Clove is mainly grown in Kanyakumari and Nilgiri districts of Tamil Nadu and in small areas in Kerala and Karnataka states. Nutmeg cultivation is more prevalent Kerala and to a limited extend in Tamil Nadu and Karnataka. Allspice is grown in few gardens of Kerala, Tamil Nadu, Karnataka, Bengal and Orissa.

Garcinia and kokum are the two potential under exploited tree spices, currently gaining much agricultural, commercial, industrial, and medicinal importance. Both are found naturally in the Western Ghats and in the evergreen forests of Khasi and Jaintia hills. Cultivation is confined to homesteads of Maharashtra and Kerala States.

Tamarind is one of the most common multipurpose trees in India, which is now being recognized as an important tree spice. In India, commercial crop of tamarind is produced in Tamil Nadu, Madhya Pradesh, Andhra Pradesh, Maharashtra and Karnataka.

Curry leaf cultivation in India is confined to the states of Tamil Nadu, Karnataka, Kerala, Andhra Pradesh, Sikkim, West Bengal and Assam.

Tejpat is an evergreen aromatic tree found in tropical and subtropical Himalayas up to an altitude of 2400 m. It is more common in North eastern India and often find its place in majority of local markets. Star anise is grown in Arunachal Pradesh. Important tree spices grown in India and their nomenclature is furnished in Table 1.

Table 1. Tree spices grown in India and their nomenclature

Sl. No.	Common name	Botanical name	Family	Part used
1.	Nutmeg	*Myristica fragrans* Houtt.	Myristicaceae	Aril (Mace), Nut
2.	Cinnamon	*Cinnamomum verum*J.Presl	Lauraceae	Bark
3.	Cassia	*Cinnamomum cassia.* Blume	Lauraceae	Bark
4.	Tejpat	*Cinnamomum tamala* (Buch Ham) Nees & Eberum	Lauraceae	Leaves
5.	Clove	*Syzigium aromaticum*(L.) Merr. & Perry	Myrtaceae	flower buds
6.	Camboge	*Garcinia cambogia* (Gaertn). Desr	Clusiaceae	Fruit rind
7.	Kokum	*Garcinia indica* Choisy	Clusiaceae	Fruit rind
8.	Pimento	*Pimento dioica*(L) Merr.	Myrtaceae	Berry, leaves

9.	Curry leaf	*Murraya koenigii*(L) Sprengel	Rutaceae	Leaves
10.	Star anise	*Illicium verum* Hook.	Illiciaceae	Fruit
11.	Caper	*Capparis spinosa* L.	Capparidaceae	Flower bud
12.	Sweet bay	*Laurus nobilis* L.	Lauraceae	Leaf
13.	Juniper	*Juniperus communis* L.	Cuppressaceae	Berry
14.	Tamarind	*Tamarindus indica L.*	Fabaceae	fruits

Out of these fourteen tree spices only seven *viz.*, nutmeg, cinnamon, clove, camboge, kokum, curry leaf and tamarind are grown commercially in India, especially in South India. Monocrops of tree spice is seldom seen in the country. Status of export and import of tree spices are furnished in Table 2. The data indicate that India is exporting mainly nutmeg, mace, camboge, cinnamon and cassia, whereas we import almost all tree spices including their oils and oleoresins.

Table 2. Import and export of tree spices in India

Spice	**Export**				**Import**			
	2015-16(P)		**2016-17(E)**		**2015-16(P)**		**2016-17(E)**	
	Qty (t)	Value (Rs. Lakhs)	Qty (t)	Value (Rs. Lakhs)	Qty (t)	Value (Rs. Lakhs)	Qty (t)	Value(Rs. Lakhs)
Nutmeg and mace	4,050	20,928.25	5,070	23,641.65	1,690	9,905.1	1,395	8,722.25
Cassia	-	-	-	-	19,405	24222.05	22,280	29062.45
Clove	-	-	-	-	20,235	104542.35	17,095	86969.90
Star Anise	-	-	-	-	4,810	9051.03	4,965	9530.0
Cinnamon, Cassia, Camboge, etc.	43,955	58,348.50	40,210	50,595.0	-	-	-	-
Oils and Oleoresins	-	-	-	-	2,005	28877.55	3,260	51182,50

Sources: Spice Board (2018)

Specific features and requirements of tree spices

Nutmeg is a dioecious or occasionally monoecious evergreen aromatic tree usually 10-20 m in height with spreading branches. Nutmeg exhibits typical dimorphic growth pattern producing orthotropic and plagiotropic shoots. It thrives well in places from sea level upto 600 m height with a warm humid climate, as in the west coast of India and the Nilgiris. A well distributed rainfall of 250 cm is ideal for the crop. Nutmeg prefers filtered sunlight and hence can be advantageously grown mixed with coconut and arecanut. The tree is dioecious in nature and the seedlings usually segregate into 1:1 male and female. Attempts to identify the sex of the seedlings at the nursery stage have not yielded any positive results. Vegetative propagation techniques *viz.,* budding and grafting have been standardized in nutmeg of which budding is commercially adopted (Miniraj *et al,.*2015). Plants budded on self (*Myristica fragrans* Houtt.) rootstocks are recommended for planting in nutmeg. Straight shoot buds (orthotropic) only are recommended for budding for the development of upright trees with spreading canopy. The root system of nutmeg is shallow and the feeding roots are confined to top soil. The tree requires a fertile soil for vigorous growth.

Cinnamon is a medium sized evergreen tree reaching a height of 15-20 m in a period of 20-30 years. The crop performs well from 300 to 350 m above MSL and thrives up to 1000 m above MSL. It flourishes in places with annual rainfall of 150-250 cm with an average temperature of 27wC. A hot and humid climate is highly suited for cultivation of cinnamon. Both seedlings and vegetative propagules can be used for planting cinnamon.

Clove is a slender, evergreen tree reaching a height of 10-15 m. It is strictly a tropical plant and requires a warm humid climate. It thrives well from sea level upto 600-1000 m above MSL with a rainfall of 150-200 cm and a mean temperature of 20-30^{0}C. Clove can be conveniently grown mixed with commercial crops like black pepper and arecanut. Seedlings are commercially used for planting.

Pimento tree grows to a height of 8-12 m. The dried immature berry is the main commercial spice product. It grows from sea level to an altitude of 1000 m above MSL. The tree flowers and fruits only at high elevation (>800 m). An annual rainfall of 100 to 200 cm or more with a mean monthly temperature upto 27^{0}C are the best for growth. The performance of allspice in plains is poor and fruiting is not observed (Krishnamoorthy & Rema 1991). Seedlings are commercially used for propagation.

Tamarind is a large, long lived evergreen tree which attains a height of 20 m or even more with girth of more than 7 m when fully grown. It is grown in semiarid, tropical, and subtropical regions and is suitable for growing in regions experiencing extended spells of dry weather. In its natural habitat, the absolute maximum temperature varies from 36 to 47.5^{0}C and absolute minimum temperature from 0-17^{0}C with an optimum rainfall of 75-190 cm and it grows upto 100 m above MSL. Best quality tamarind is obtained from dry weather areas.

Camboge is a small to medium sized tree with oval shaped crown having orthotropic and plagiotropic branches. The species is androdioecious in nature. It is a very hardy crop and can be grown in tropical and subtropical climates under fully open conditions.

Kokum tree is very strong and sturdy in growth. It grows on wide range of soils, from marginal to deep alluvial, which are well drained. Optimum growth is at temperature ranging from 20^{0}C to 35^{0}C, 60 to 80% humidity and well distributed rainfall ranging from 250 to 400 cm.

Curry leaf is a hardy crop. It can tolerate higher temperature but when the temperature falls below 16^{0}C the vegetative buds become dormant, arresting new growth. It grows at an altitude range of 60-1200 m above MSL. Seedlings as well as root suckers are used for commercial cultivation.

Tejpat trees grow best in a warm humid climate at an elevation of 1500-4000 m from MSL with an average temperature of 30^{0}C and 150-200 cm rainfall per annum. It can be grown in poor soils, however sandy loam soils with a mixture of humus or vegetative mould is the best for production of fragrant leaves (Farooqi *et al*. 2005). Tejpat is propagated by seeds.

Star anise trees require warm climate and abundant rainfall of above 130 cm and 78% relative humidity. It is a shade tolerant tree. It grows best in the light acid soils with high content of humus. It is propagated by seeds.

Status of Spice production in NER

The availability of wide genetic resource base and varying production systems in NER ensures sustainable production of different spice crops. It is anticipated that the region can create exportable surplus of various spice crops at competitive prices so that the top slot occupied by the country in international market for spices would be maintained.

Status of spice production in NER region (2016-17) is presented in table 3. An area of 1, 40, 241 ha is under spice production with an annual production 1,37,514 tonnes (Hnamte *et al*. 2012). Among the different spices grown in the region, three commercial crops are ginger, turmeric and large cardamom. Among all spices, ginger is the main cash crop supporting the livelihood and improving the economic level of many farmers of north eastern region.

Ginger is grown in almost all the states of the region but the leading states are Meghalaya, Mizoram, Arunachal Pradesh and Sikkim. Ginger is already a well-established cash crop in Meghalaya and Mizoram with highest productivity in the country. Large cardamom farming as an under storey crop in hill slopes of Sikkim is a unique traditional production system. Black pepper is also showing promise and organic production is possible to a limited extent.

Table 3. Status of spice production in NER 2016-17 (Provisional)

State	Ginger		Chillies		Turmeric		Garlic		Coriander	
	A	P	A	P	A	P	A	P	A	P
Arunachal Pradesh	7.70	56.60	3.0	8.30	0.80	3.80	-	-	-	-
Assam	18.70	166.50	21.60	19.40	17.10	17.0	29.70	56.0	29	29.7
Manipur	2.40	3.80	6.50	3.90	1.40	16.40	0.20	0	-	-
Meghalaya	9.90	66.40	2.30	2.20	2.60	16.60	0.30	1.1	0	0.01
Tripura	1.80	7.60	2.40	3.70	1.30	6.60	-	-	-	-
Nagaland	3.70	50.20	6.80	45.50	0.70	9.10	0.30	2.90	0.10	0.20
Mizoram	8.20	60.0	9.20	9.30	7.20	27.80	-	-	0.10	0.00
Sikkim	12.30	55.90	-	-	2.0	5.70	-	-	-	-

Source: Horticulture Statistic Division, Dept of Agriculture, Co-operation and Farmer Welfare (2017)
A = area in '000 ha, P= production in '000 mt

Suitability of NER for tree spices

North Eastern region of India, comprise of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The region is categorized by diverse agro climatic and geophysical features which make the region distinctive in many ways. Physiographically the entire NE India is divided into four well differentiated units: i) the eastern Himalayan region, ii) the eastern mountain region, iii) the Meghalaya- Mikir tabl eland and iv) the Brahmaputra valley. The states harbour a rich flora and has abundant potential for the development of crops like tree spices. The total geographic area of NE region is 262,180 square km which is nearly 8% of the total geographic area of the country (Yadav *et al*. 2003). The region represents wide variation of climate ranging from cold to warm pre-humid and receives mean annual rainfall exceeding 2000 mm per annum. The annual precipitation received in the region comes largely from south-west monsoon, which sets around middle of May and continues till the end of October. The greater part of the region has subtropical climate. However, the climate of NE region varies from near tropical in the plains of Assam, Tripura and south Mizoram to near alpine in the northern Sikkim and Arunachal Pradesh (Ngachan *et al*. 2011). The soils of the region are usually rich in organic matter and acidic to strongly acidic (pH 4.5-5.0) in reaction and thus suitable for growing different spice crops (Hnamte *et al*. 2012). The North Eastern region faces vagaries of high rainfall and consequently nutrient depletion and the soil erosion occur. Of the total geographical area of Eastern Himalayan region, 35% lie in the elevation range of below 150 m, 26% between 150-1200 m and 18% between 600-1200 m. Agro-climatically the region is known for its wide diversity representing temperate, subtropical and tropical areas. In general the soil and climate of NER are highly suited for the production of tree spices.

Potential of tree spices in NER

North eastern states have great potential for large scale cultivation of tree spices due to their varied agro-climatic region, topography and soil. This region can be the major exporting centres of these spices as the region act as a window of trades to the Eastern countries. Majority of the community feasts of NER which include vegetarian and non-vegetarian items require most of the tree spices and at present their requirement is met from other states. Tree spices like cinnamon, tejpat, nutmeg, curry leaf, allspice, and clove are found growing in small pockets in NER. The region where the temperature does not fall below 15^0C has immense potential of growing tree spices commercially. Moreover, NER is famous for the plantation crops like coconut, arecanut, coffee etc. Area under Arecanut in Assam (76.84 thousand ha), Arunachal Pradesh (1.02 thousand ha), Mizoram (10.70 thousand ha), Meghalaya (17 thousand ha), Nagaland (0.50 thousand ha), Tripura

(4.70 thousand ha) and the area under Coconut in Assam (24.71 thousand ha), Arunachal Pradesh (0.07 thousand ha), Mizoram (0.04 thousand ha), Nagaland (0.33 thousand ha), Tripura (7.13 thousand ha) offer great scope for mixed/inter cropping with tree spices , there by improving the unit area productivity. At present, most of these two plantation crops are under monocropping except in Assam where multistory cropping system is practiced. The space available under coconut and arecanut can be efficiently utilized by planting tree spices like nutmeg and clove which prefer partial shade for growth and production.

Arunachal Pradesh is the largest state in North East India, with large areas growing spices like tejpat. Cinnamon is found growing naturally in the state. Star Anise, a spice originated in China is found growing in the China border. The gateway of Northeast, Assam has been growing many tree spices like cinnamon, nutmeg, clove, tejpat and allspice. In Manipur, tree spices like true cinnamon and tejpat are grown in the kitchen garden, but mostly they are collected from the wild. Mizoram is one of the leading states under organic farming in India. Mizoram has produced spices like ginger, turmeric, black pepper, herbal spices and also" birds eye chilli" which is a brand in spices market abroad. Wild cinnamon and tejpat are the tree spices grown in the state.In Meghalaya, true cinnamon and tejpat are priority tree spices. Garcinia and kokum are found in the evergreen forests of Khasi and Jaintia Hills. The other tree spices like allspice and curry leaf are grown occasionally in homestead gardens. Nagaland is famous worldwide for its hot spice, king chilli or Raja Mircha (the hottest chilli man has ever tried). Cinnamon is grown in the high altitude regions of Nagaland. Tripura, which is rich in natural and mineral resources, grows true cinnamon trees in the backyard of most of the houses. Other tree spices like tejpat and nutmeg are also grown sporadically in this state. Sikkim produces major spices like chillies, turmeric, and ginger and large cardamom, but not any tree spice. Even though the land holding size is small in NER, all the tree spices can be grown either as a homestead crop or as inter/mixed crop.

Scope of organic tree spices in NER

The world demand of organic food including spices is increasing rapidly. NER being a largely organic region has huge scope on the production of tree spices under organic management. The land of NER is almost virgin and farming practices are virtually organic which make ample scope for speedy organic certification and export. Hence, Promotion of organic cultivation of tree spices in this region needs special attention.

Scope of value addition in spices

In North Eastern region, a huge quantity of good quality spices are produced, but most of the growers during peak season sell their produce at throw away prices in the local market or to the commission agent. There is vast scope for making value added products from spices like oils, oleoresins and powders. Pastes from ginger and turmeric; pepper and ginger in brine; curcumin from turmeric; capsanthin and capsaicin from chillies; candy, cookies, flakes, beer, wine and juice from ginger, white, dehydrated, freeze dried canned, bottled and dehydrated salted green pepper etc. can be prepared in view of their high demand. Rind of nutmeg can be made into wine, candy, cake, pickles, osmo dehydrated chunks, syrup, jam, jelly, mouth freshners, *etc*. (Miniraj *et al*,. 2016) Volatile oil from bud, stem, roots, mother cloves of clove; tamarind kernel powder (TKP), tamarind concentrate and kernel oil from tamarind; dried kokum rind, kokum syrup (Amrit Kokum), dried ripe kokum rind, kokum gal (brined kokum juice) from kokum are some other products becoming popular in tree spices. Value addition assures better prices in the market.

Underexploited tree spices of NER

The NER also serve as the natural habitat of several lesser known tree spices. *Zanthoxylum* species prevalently known as Sichuan pepper are the plants belonging to the family Rutaceae which have about 250 species distributed all over the world, of which 11 are reported from India. *Z. acanthopodium, Z. armatum* and *Z. oxyphyllum* are found in North Eastern India (Kala *et al*. 2005). Among them, *Z. armatum* commonly known as Prickly Ash or Toothache Tree and locally as

*Mukthrub*i (Manipur) is an erect shrub or a small tree. A perennial erect shrub with prickly stem, *Z. acanthopodium* is 250-300 cm tall with brown densely matted hairy branches (Yonzone & Rai 2016). *Z. oxyphyllum* is a slender climbing shrub found in Upper Assam, Manipur and Meghalaya. Another species *Z. rhesta* is a deciduous tree, large crown toughened with sharp spines on the branches (Patiri & Borah 2007). All these species of *Zanthoxylum* offer great scope for exploitation.

Even though *C. tamala* is the accepted source of tejpat, other species like C*. impressinervium* Meissn., *C. bejolghota* and *C. sulphuratum* are used as tejpat in certain pockets of NER. The utilization of these species is still confined to NER and further research is needed for their popularization.

Garcinia atroviridis Griff ex T. Anders is a medium-sized tree that belongs to the Guttiferae family, locally known as *Asamgelugor*. It is distributed in NER, mostly in Assam in which the unripe fruits are used in curries (Baruah & Borthakur 2012). The cut and dried pieces of rind are used for souring curries and for dressing fishes as a substitute of tamarind.

Sichuan peppers, other cinnamon and garcinia species are famous elsewhere for their characteristic flavor and aroma. However, the utilization of the species in India is restricted to few local people in the NER. Recorded history show that apart from being used as spices they have medicinal properties too. There is urgent need for conserving these lesser known spice crops of the NER and research need to be geared up for their popularisation.

Conclusion

The food habit of people of NER include the use of tree spices and their products, but the production is very much limited, most often confined to kitchen gardens or collection from the wild. Tremendous scope exists for expanding the area of tree spices in the NER either as homestead crop or as an inter/mixed crop with other perennial crops. The agroclimatic conditions are ideal for the tree spices, as also the possibilities for organic production. By judicious selection of crops and scientific cultivation practices, these perennial spice crops can well be fitted into the existing cropping systems prevailing in the region.

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ORAL PRESENTATIONS

OP1

Direct and indirect effects of yield attributes on berry yield in black pepper (*Piper nigrum* L.)

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Characterization of 40 black pepper germplasm accessions, collected from black pepper growing tracts of Kerala and Karnataka, and maintained at the ex-situ gene bank of ICAR-IISR, Kozhikode was carried out during 2016-17. Data were recorded on 15 qualitative and 15 quantitative traits as per the descriptor developed by IPGRI. Distinct variation was observed for all the qualitative traits except spike fragrance. High coefficient of variation (CV) was observed for fresh weight and spikes per vine where as low CV was recorded for fruit size. Among all accessions, Acc. 7542 recorded highest fresh yield (6.25 kg per vine). High positive correlation was observed between fresh berry weight per vine and dry berry weight per vine (0.971) followed by spike per vine and fresh berry weight per vine. Path coefficient analysis revealed high positive direct effect of fresh weight per vine on dry weight per vine (1.048). Whereas number of spikes per vine through fresh berry weight per vine had high positive indirect effect on dry berry weight per vine. Residual effect was low (0.114) indicating that the characters studied account for 89% variability. It can be concluded that traits like number of spikes per vine and fresh berry weight per vine are the important traits to target during selection process in black pepper breeding.

OP2

Establishment of micropropagation protocol for large cardamom (*Amomum subulatum* Roxb.) cv. Varlangey

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Microprapagation protocol was established in *Amomum subulatum* Roxb. (cv. Varlangey) using the young shoots as explant for the production of disease free and rapid multiplication of planting material of large cardamom in Sikkim. The explants were cultured in MS medium with 4.0% sucrose and 8.0% agar supplemented with different combination of growth regulators. The 12 different combinations of growth hormones in the culture medium were examined. Among treatments, MS + KIN 3 mg L^{-1} + NAA 0.5 mg L^{-1} showed highest survival percentage with best shoot proliferation, average days taken for root and shoot initiation, shoot proliferation rate, root proliferation rate, length of shoots, length of roots. Whereas, medium MS + BAP 3.0 mg L^{-1} + NAA 0.5 mg L^{-1} showed best result in root proliferation and highest length of shoot (12.23 cm). The treated plantlet was successfully acclimatized in pot by placing transparent polythene over pot for 10-12 days.

OP3

Performance of turmeric genotypes in Arunachal Pradesh for yield and quality

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Performance of ten turmeric genotypes along with national check, IISR Pratibha and local check, Megha Turmeric-1 was studied at College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh during 2013-14 to 2016-17 in RBD with three replication in a sandy loam soil. Among the genotypes, tallest plant stature was recorded in NDH-98 (103.95cm) which remained at par to Megha Turmeric-1 and NDH-8 while the minimum plant height was observed in SLP389/1 (79.88 cm). Maximum number of tillers per plant was recorded in NDH-98 (4.28) which remained at par to Acc.48, NDH-8, NDH-79, TCP-64, PTS-12 and Megha Turmeric-1 while minimum number of tillers per plant was recorded in Acc.79 (2.83). The genotype SLP389/1 took minimum days (204.17) for maturation and it did not differ significantly with the other genotypes except NDH-8, NDH-98 and PTS-12. The genotype NDH-98 recorded maximum rhizome yield (30.75 t/ha) and it showed significant superiority over other genotypes as well as both the check varieties. Lowest rhizome yield was recorded in genotype TCP-64 (12.90t/ha). The genotype NDH-8 recorded highest dry recovery (24.57%) as well as better quality such as curcumin (6.4%), essential oil (7.40%) and oleoresin (12.91%) contents. It can be concluded from the present study that genotypes NDH-98 and NDH-8 performed better in terms of yield and quality respectively.

OP4

Biochemical characterization of unique genotypes of nutmeg (*Myristica fragrans* Houtt.)

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Nutmeg (*Myristica fragrans* Houtt.) is a crop of high food as well as pharmaceutical value. In the present study, some unique nutmeg accessions possessing distinct features are characterized biochemically in order to assess its further application in both food and pharmaceutical industry. The research was carried out at Department of Plantation Crops & Spices, College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala. Thirteen unique genotypes collected from diverse locations of Kerala formed the material for study. Among the unique nutmeg genotypes, significant variation was observed in terms of volatile oil composition of mace and nutmeg. Seedless nutmeg had highest volatile oil recovery in mace whereas grape nutmeg had highest kernel oil recovery. In terms of oleoresin, wild nutmeg accession possessed highest oleoresin content in mace and monoecious nutmeg accession had significantly higher oleoresin content in kernel. Fixed oil present in kernel was high in cluster fruited nutmeg. Chemoprofiling studies of mace and kernel oil identified 38 constituents, of which major shares were for myristicin, elemicin, sabinene and safrole. Chemoprofiling of mace oil detected high myristicin content in grape nutmeg. Sabinene content of the kernel oil of oblong nutmeg was significantly higher

compared to other types. The rind of seedless nutmeg recorded low acidity content. Double seeded nutmeg possessed low tannin content. Pectin content in nutmeg rind varied from 0.18-11.65%. Yellow maced nutmeg had high starch content in rind. Chemical constituents present in nutmeg and mace of these distinct accession offer immense application in medical and food industries. Unique nutmeg with good rind processing qualities like low tannin and acidity content offer great scope in value addition sector.

OP5

Plantlet regeneration and acclimatization of King Chilli (*Capsicum chinense* Jacq.) through *in vitro* technique

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The present investigation was undertaken at the Tissue Culture Laboratory, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University. The popular genotype *Capsicum chinense* Jacq. cv. king chilli was selected for the study for its pungency and unique aroma. To standardize the protocol for plantlet regeneration, the experiment was undertaken using shoot tips as explants following CRD replicated thrice. Shoot tips (1–2 cm) explants were cultured on MS medium supplemented with various concentrations of either BAP or kinetin @ 0, 2, 48 mgL^{-1} respectively for callus formation and shoot proliferation, alone and in combination with 0.5 mgL^{-1} IAA. The medium containing 8 mgL^{-1} BAP + 0.5 mgL^{-1} IAA recorded the maximum response (83.33%) for shoot proliferation, highest number of shoots (3.39) and longest shoot length. The highest shoots (4.37) were proliferated during the third subculture with maximum length (1.7 cm) of the bud. Regenerated shoots underwent fair shoot elongation of 2.5-4 cm on transfer to growth regulator free MS basal medium. Well elongated shoots were transferred to MS medium supplemented with various concentrations of auxins *viz*., IBA and IAA @ 0, 0.2, 0.5, 0.8, 1, 1.2 and 1.5 mgL^{-1} alone for root formation. The medium supplemented with 1 mgL^{-1} IBA recorded highest number of functional roots (11.36 per explant). After four weeks, shoots with several well ramified rooted plantlets were hardened under controlled conditions and recorded 70% survival.

POSTER PRESENTATIONS

PP1

Influence of grafting on growth of black pepper varieties in coastal region of Karnataka

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Black pepper (*Piper nigrum* L.) is a vegetatively propagated crop and is commonly propagated using cuttings from orthotropic or runner shoots. There has been reduction in production of black pepper, mainly due to Phytophthora foot rot. Grafting technique of propagation is one of the methods to overcome this. *Piper colubrinum* is found to be a tolerant rootstock for Phytophthora foot rot which has graft compatibility with *Piper nigrum*. However, there have been no studies on the response of grafting to different varieties of black pepper. This experiment was undertaken to study the response of different varieties to grafting in coastal region of Karnataka. This experiment was conducted at Antharvally (Kumta taluk, Uttara Kannada dist. Karnataka). A total of 25 varieties were grafted *in situ* on *Piper colubrinum* as rootstock on *Acacia mangium* as live standard tree. The growth parameters were recorded at 15 days interval. The results revealed that plant height, number of leaves, leaf length, leaf breadth, leaf area and stock girth were found to be maximum in Panniyur-1. Number of nodes was found to be maximum in Bilimalligesara and internodal length was found to be maximum in Thekkan-2. The IISR-Malabar Excel and Tirupukare produced more branches while Panchami produced more sprouts. The scion girth was found to be maximum in var. Pournami. Further growth and yield characters are being studied to evaluate them for their response to berry yield and quality.

PP2

Performance of black pepper germplasm accessions under Yercaud condition

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In Black pepper, a total of 78 accessions are being maintained at TNAU, Yercaud centre, Tamil Nadu, as part of germplasm conservation. In the year 2016-17, among the 72 accessions the good berry set was observed in 28 accessions. The yield characters viz., spike length, number of berries per spike, 100 green berry weight, 100 dry berry weight, green berry yield and dry berry yield were recorded. Among the 28 accessions, the significant difference was observed for the characters spike length, number of berries per spike, 100 green berry weight, 100 dry berry weight, green berry yield and dry berry yield. The spike length was the highest in PN 77 (12.4 cm) followed by PN 62 (12.2 cm) and PN 46 (12.0 cm) and the lowest in PN 5 (7.7 cm). The accession PN 72 had more number of berries per spike (78) whereas only 36 berries were observed in the accession PN 8. The 100 green and dry berry weight were highest in the accession PN 64 (16.1 g and 5.5g) followed by PN 77 (13.8 g and 4.62 g) and the lowest in the accession PN 73 (8.2 g and 2.74g). The accession PN 11 recorded the highest green berry yield per vine (3.11 kg) and dry berry yield per vine (1.048

kg). The accession PN 58 recorded the lowest green berry yield per vine (1.2 kg) and dry berry yield per vine (0.418 kg).

PP3

Genetic diversity in large cardamom (*Amomum subulatum* Roxb.)

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Large cardamom (*Amomum subulatum* Roxb.) is one of the oldest spices used by man. India is the largest producer of large cardamom in the world with 54% share, followed by Nepal (33%) and Bhutan (13%). It is a member of Zingiberaceae family, is one of the main cash crop cultivated in the sub-Himalayan mountains at an altitude ranging from 800-2000 m. This crop thrives well in 6°C to 25°C with well distributed annual rainfall of 200-350 cm. It is one of the main cash crops cultivated in Sikkim, Darjeeling district of West Bengal, Nagaland, Uttarakhand, Manipur, Arunachal Pradesh and some other parts of the North Eastern India covering an area of 26400 ha with an annual production of 5000 metric tons. Indian Cardamom Research Institute (ICRI), Spices Board, Regional Station, Gangtok conserved 301 accessions of large cardamom in the genebank. Large cardamom seedling population has large variability due to cross pollination and hence is very rich in its genetic diversity. Because of the wide range of altitudes it inhabits, there are different cultivars adapted to different altitudes and agro-climatic conditions. There are mainly six cultivars of large cardamom *viz*., *Ramsey, Ramla, Sawney, Golsey, Varlangey* and *Seremna.* Another cultivar Bebo is also getting importance and is spreading to more areas in Arunachal Pradesh. Cultivars suited for high altitudes (>1515m MSL) are *Ramsey*, *Varlangey* and *Ramla*. *Sawney* is suited for mid (975 – 1515 m MSL) altitudes and cultivars *Golsey* and *Seremna* are suited for low (<975m MSL) altitude areas. There are distinct cultivars suited to different altitudes and diverse agro-climatic situations, hence there is a scope for introduction and area expansion of suitable cultivars in the NE states.

PP4

Comparative study on the performance of ginger variety Suprabha and local variety in Zunheboto district, Nagaland

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Ginger is one of the most important spices cultivated crop in Zunheboto district in Nagaland. In this context Krishi Vigyan Kendra, Zunheboto conducted an experiment to find out the suitable variety which can replace local variety. Experimental finding suggest that Suprabha variety and local yielded 13 and 9 tons per hectare respectively. Average weight of rhizomes per plant were 176 g and 150 g respectively for Suprabha and local variety. Cost of cultivation was Rs. 77,000 per hectare for both the varieties however; gross income was Rs. 1,30,000 and 90,000 respectively for Suprabha and local variety. Benefit cost ratio of 1.68 and 1.16, was obtained for Suprabha and local variety. These findings suggested that Suprabha variety yielded more and can be taken up by the farming community to get better income which will help in increasing the socio-economic condition of farming community.

PP5

Evaluation of variability in ginger for morphological and biochemical traits under Shivalik Hills

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Ginger (*Zingiber officinale* Rosc.), one of the most important spice crops and many local cultivars identified by their locality are prevalent in the hills of Shivaliks. To identify the promising local cultivars, a study was conducted for phenotypic characterization and variability estimation in the 61 genotypes of ginger based on various morphological characters evaluated over a period of two successive years (2016 and 2017). The analysis of the data suggested significant intra and inter clusters. Significant variability was observed for all characters viz., plant height, shoot height, shoot diameter, number of shoots, leaf length, leaf width, leaf area, leaf petiole, number of leaves on main stem, rhizome length, rhizome breadth, number of fingers/rhizome and yield/plant. High phenotypic and genotypic coefficient of variations were recorded for yield/plant, plant height, shoot height in both the years indicating high potentiality of these traits for effective selection. These traits also showed high genetic advance in the respective years which indicated the role of additive gene action for the inheritance of these traits and are likely to respond better to selection. In the present study, it was concluded that shoot height, shoot diameter, number of shoots per plant, rhizome length and girth should be given due consideration for the improvement of yield. In addition, 15 potential local genotypes selected on the basis of field evaluation were analyzed for biochemical components such as essential oil, oleoresin content and crude fiber. These promising lines/cultivars may further be given due attention for conservation.

PP6

Field performance studies of ginger microrhizome produced through *in vitro* technique

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Ginger (*Zingiber officinale* Rosc.) is generally vegetatively propagated through mature rhizome segments but is highly susceptible to bacterial and fungal pathogens which are difficult to eliminate through conventional methodologies. Tissue culture is one technique which can be efficiently and conveniently used to acquire disease free stock of source material. Hence, ginger cultivar 'Nadia', was propagated through tissue culture technique. The plantlets produced from MS medium + 3 mgl^{-1} BAP containing different growth regulators were evaluated under open field condition. Survivability percentage of plants after 90 days of planting was maximum (100%) under the plants

raised in media combination with 2 mgl^{-1} IAA; 1 mgl^{-1} IBA and 2 mgl^{-1} IBA. Maximum average yield per clump (225.33 g) was recorded in plants raised in media containing 2 mgl^{-1} NAA. The highest number of primary fingers (6.00) was recorded in plants raised in media containing 1.5 mgl^{-1} NAA and secondary fingers (5.67) in 1.5 mgl^{-1} NAA. *In vitro* regenerated plants of ginger cv. Nadia showed highest projected yield (36.3 t/ha) which was higher than the conventional method of cultivation. This study highlights the superiority of plantlets derived from tissue culture compared to conventional cultivation method.

PP7

Induction of tetraploids in ginger cv. IISR Rejatha

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Ginger (*Zingiber officinale* Roscoe) is a very important spice cum medicinal plant known to mankind since time immemorial. The major crop improvement objectives in ginger are high yield, bold rhizomes, low fiber, resistance to diseases (such as rhizome rot, bacterial wilt, and *Fusarium* yellows) and improvement in essential oil and oleoresin. Polyploidy breeding is one of the frequently used methods in vegetatively propagated horticultural crops. Induction of tetraploids using the chemical colchicine has been successfully tested in a few varieties of ginger earlier. Vegetative vigor associated with tetraploidy can be successfully used in a crop like ginger to develop low fibre varieties used for vegetable purpose and confectionery. Besides, improved pollen fertility associated with tetraploidy in ginger may be helpful in utilizing them for studies on induction of fruit and seed set. Thus, developing teraploids of different ginger varieties may be feasible for selection of suitable ones to be used as commercial varieties as well as for seed set studies. The present study reports *in vivo* induction of tetraploids in a commercial variety of ginger namely IISR-Rejatha using colchicine. The freshly emerging buds from the rhizomes of cv. IISR-Rejatha were treated with different concentrations of aqueous solution of colchicine (0.0, 0.025, 0.05, 0.075 and 0.1%) at different time durations (24 h and 48 h). Maximum sprouting was recorded in colchicine concentration of 0.025% at 24 h treatment. The colchicine concentrations above 0.1% was found to be lethal. The chromosome number analysis of rhizomes harvested from the plants derived from colchicine treated buds confirmed tetraploidy (2n=44) in two of them. Both these were derived from buds treated with 0.1% colchicine for 48 h (0.1/48/3 and 0.1/48/5). These two promising tetraploids are being multiplied and characterized.

PP8

Mass multiplication of ginger cv. Nadia for the production of microrhizomes

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Ginger (*Zingiber officinale* Rosc.) is generally vegetatively propagated through mature rhizome segments but is highly susceptible to bacterial and fungal pathogens which are difficult to eliminate through conventional methodologies. *In vitro* technique can be efficiently and conveniently used to acquire disease free stock of source material. Ginger cultivar 'Nadia', was used in this study to standardize the protocol for mass multiplication to produce disease free microrhizomes. Different concentrations and combinations of BAP, IBA, NAA and IAA were used with MS medium and a total of 15 different media combinations for shoot proliferation using shoot tip as explants were tried. The results of the experiment revealed a wide range of variation in days required for callus initiation. The least number of days for callus initiation was observed in 3 mgl^{-1} BAP supplemented media and shoot proliferation started 20.43 days (3 mgl^{-1} BAP + 0.5 IBA) after inoculation. The maximum number of shoots per explant was obtained in the media containing 3 mgl^{-1} BAP + 0.5 mgl^{-1} IBA (3.6 shoots per explant). The MS media in combination with 3 mgl^{-1} BAP enhanced the rate of shoot multiplication within 3 weeks whereas media combination of 1 mgl^{-1} BA with 0.5 mgl^{-1} IBA and NAA showed very less response with high callusing but abnormal shoots. The highest microrhizome weight was recorded (246 mg) in 3 mgl^{-1} BAP + 0.5 mgl^{-1} NAA.

PP9

Assessment of genetic parameters for morphology and yield attributes in turmeric (*Curcuma longa* L.)

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The research work pertaining to the study of genetic parameters for yield and yield contributing characters in 15 diverse elite lines and cultivars of turmeric was conducted during 2016-17 at the Experimental Farm, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala. Observations on eight qualitative traits were recorded in the form of multiscale scores given by DUS guidelines. Among, the qualitative characters, purple colour of the emerging shoot was recorded in SLP 389/2; leaf disposition was horizontal in SLP 389/2, erect in BSR 2, IISR Prathiba, CO2, Acc 849, Narendra Haldi 98, Megha Turmeric and Duggirala Red. Wavy leaf margin was recorded in IISR Prathiba, IISR Pragati, Duggirala Red and all other genotypes studied falls under even leaf margin category. Coma bract was coloured in Acc 849, NDH 98, Megha Turmeric, SC 61, Suvarna, Varna and Rajapuri. Rhizome habit was loose for SLP 389/2 and Punjab Haldi 1, intermediate in Duggirala Red, CO2, IISR Pragati and SC 61. Rhizome colour was yellow in 26 % of genotypes studied, orange in 33% and 40 % in reddish orange colour category. Genetic variability for 24 quantitative characters was recorded in 15 genotypes. High GCV and PCV were observed for 16 characters except for plant height (cm), Leaf length (cm), leaf width (cm), primary rhizome length (cm), secondary rhizome girth (cm), primary rhizome diameter (cm) and inner core length (cm). High heritability coupled with high genetic advance as per cent of mean was observed for 22 characters except primary rhizome girth and secondary rhizome girth. Greater magnitude of broad sense heritability coupled with higher genetic advance for most of the characters revealed that the simple selection should lead to a fast genetic improvement of the genotypes used. Highest yield was recorded in Acc. 849 (728.45 g/plant) followed by IISR Pragati (577.93 g/plant). High curcumin was recorded in IISR Pragati (5.75%) followed by Rajendra Sonia (5.54%).

PP10

Evaluation of turmeric genotypes for their resistance against foliar diseases

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Turmeric (*Curcuma longa* L.) is widely used as spice, condiment, dye and medicine. The fungal diseases like leaf spot (*Colletotrichum capsici)*, leaf blotch (*Taphrina maculans)* and rhizome rot (*Pythium aphanidermatum)* are the major production constraints which causes huge yield loss. The sources of tolerance/resistance to these diseases are not available. Therefore, a field trial was laid out with 15 high yielding genotypes across India to screen against foliar diseases during 2012-13 to 2015-16. Out of 15 genotypes NDH-128 (7.87PDI) was found to be resistant, whereas, CL-34 (20.40PDI), TCP-14 (14.12PDI), TCP-129 (13.94PDI) and NDH-10 (24.2PDI) were moderately resistant and CL-32 (29.21PDI), CL-52 (26.08PDI), CL-54 (32.22PDI), RH-406 (35.91PDI), RH-407 (31.92PDI), RH-410 (31.46PDI), TCP-16 (27.98PDI), NDH-40 (33.59PDI), NDH-74 (34.51PDI) and NDH-1 (38.77PDI) were susceptible against leaf spot. None of genotypes were found immune and highly susceptible. These genotypes showed moderate resistance to moderate susceptible disease reaction with 20.89-44.12 PDI against leaf blotch disease. NDH-10 recorded maximum fresh rhizome yield (350.51 q/ha) followed by NDH-74 (298.63q/ha) and NDH-1 (293.04 q/ha).

PP11

Performance of turmeric varieties Roma and Megha Turmeric-1 in Zunheboto district

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Turmeric (*Curcuma longa*) is cultivated in some of the blocks of Zunheboto district which has got immense medicinal uses. The present experiment was conducted at several locations to find out the performance of these varieties. Experimental result showed that the average yield was 23.8 and 33.9 t/ha respectively for Roma and Megha Turmeric-1. Average weight of rhizomes/plant for Roma and Megha Turmeric was 396 and 565 g respectively and number of rhizomes per plant was 39 and 43 respectively for Roma and Megha Turmeric-1. Cost of cultivation ha^{-1} was Rs. 1,40,500 and Rs. 1,28,000; gross income ha^{-1} was Rs. 4,76,000 and Rs. 6,78,000; net profit ha^{-1} was Rs. 3,35,500 and Rs. 5,50,000 with a BC ratio of 3.38 and 5.29 respectively for Roma and Megha Turmeric-1. From the above results, it was concluded that the performance of Megha Turmeric-1 was better than the Roma variety and can be taken up by the farmers for increasing their productivity.

PP12

Identification of water-logging tolerant genotypes in turmeric for Chhattisgarh

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Turmeric requires warm and humid climate with temperature range of 24°C to 28°C with annual rainfall range from 800 mm to 1500 mm. Its active growth is restricted when temperature falls below 20°C, and hence early–planted turmeric yields better under Chhattisgarh condition. The crop cannot tolerate waterlogging. During 2016-17, Raigarh district of Chhattisgarh received annual rainfall of 1250 mm. In this study, a total of 98 genotypes were screened for water logging tolerance during Kharif 2016 at CARS, Raigarh. All the genotypes were grown in randomized block design with two replications with 3 x 1 m plot size. Results showed that 30 out of 93 genotypes were susceptible to water logging. Among the genotypes tested, IT- 10 recorded maximum rhizome yield (24.08 t ha^{-1}) followed by IT 36 (23.3 t ha^{-1}) and IT- 23 (22.2 t ha^{-1}).

PP13

Assessing the genetic relatedness using the fruit and quality characteristics of elite clones of nutmeg (*Myristica fragrans* Houtt.) from Kerala

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An explorative survey was taken up by Kerala Agricultural University to locate super trees of nutmeg from farmer's holdings in Kerala. Twenty nine plus accessions were located and they were subjected to mother tree characterization for three consecutive years from 2014 to 2017. Yield contributing characters as well as quality parameters were assessed in the trees of uniform age. The statistical parameters *viz.*, mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H^2) and genetic gain (GG) were calculated. Fresh nut weight ranged from 0 to 21.18 g, dry nut weight from 0 to 15.43 g, kernel weight from 7.44 to 9.66 g, fresh nut weight from 4.7 to 6.26 g, dry mace weight from 2.41 to 3.89 g, number of fruits $tree^{-1}$ from 600 to 2300, kernel oil from 0 to 12.5%, mace oil from 3.3 to 12.5%, kernel oleoresin from 0 to 16.99 %, mace oleoresin from 13.0 to 41.8% and fixed from oil 0 to 40.8%. High PCV and GCV were observed for all the characters studied. High GCV coupled with high heritability in the characters indicated the scope for yield improvement through selection based on characters observed. Genetic gain was the highest for kernel oil per cent (83.98%) followed by dry mace weight, number of fruit per tree and kernel weight. Hence, selection programme based on number of fruits per tree, kernel weight, dry mace weight as well as quality character such as kernel oil will lead to improvement in the base population. Data on yield and quality characters were employed in hierarchical clustering which classified the accessions into five groups. This grouping of morphotypes was in conformity with their expression of yield and quality characters. High genetic variability including some unique characteristics existing in this crop were also observed.

PP14

Enhancement in yield of nutmeg (*Myristica fragrans* Houtt.) through pruning

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Nutmeg (*Myristica fragrans* Houtt.) is an evergreen aromatic tree, usually grows to a height of 10-20 m or even more with spreading branches. In commercial cultivation, development of suitable canopy structure would help to bear more number of fruits with synchronized flowering which facilitates ease of harvest. With this back ground, an experiment was set up to study the effect of pruning on nutmeg yield at ICAR- Indian Institute of Spices Research, Regional Station, Appangala, Karnataka during 2014-2017. The treatments consisted of cutting all the side plagiotropic branches at varying length of 1 m, 2 m and alternative side branches cut at 1m and 2 m length and control (without pruning). All the trees under study (including control) were detopped at a height of 17 ft. The treatments were replicated eight times. The observation on number of fruits, weight of nuts (fresh and dry) and weight of mace (fresh and dry) were recorded. No significant difference in yield parameters were observed in the first two years of pruning however, in third year, an increase in yield were recorded in moderately pruned trees (all side branches cut at 2 m and alternative side branches cut at 1m and 2 m length) as compared to control (un pruned) and severely pruned trees (all side branches cut at 1 m length). In third year of pruning, the side branches pruned at 2 m length produced more fresh (3136 g) and dry (1286 g) weight of nuts, fresh (536 g) and dry (548.50 g) weight of mace and number of fruits (205.37) over control. Hence, detopping combined with pruning all the side branches at 2 m length can be adopted to enhance yield in nutmeg.

PP15

Correlation coefficient and path analysis in coriander (*Coriandrum sativum* L.)

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Coriander is one of the important seed spice grown in India. Correlation and path analysis will establish the extent of association between yield and its component and also bring out the relative importance of their direct and indirect effects and thus, gives a clear understanding of their association with yield. Keeping this in view, the present investigation was conducted study the association among characters and path analysis in M_2 progenies of coriander. Data collected on 11 characters in the progenies was subjected to components of variance. Phenotypic correlation coefficient was utilized for path coefficient analysis. The direct and indirect contribution of various traits was calculated through path coefficient analysis. The data revealed that seed yield per plant was found to be significantly and positively correlated with plant height, number of primary branches per plant, number of umbels per plant, umbellets per umbel and number of seeds per umbel. The perusal of path coefficient analysis showed that, the highest positive direct effect on seed yield was exhibited by mericarps, number of umbels and umbellets per umbel. Therefore,

greater emphasis should be given on these characters while selecting for higher yield and related traits.

PP16

Correlation studies and path analysis in coriander (*Coriandrum sativum* L.)

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Sixteen coriander (*Coriandrum sativum* L.) varieties were evaluated during November 2016 to February 2017 to estimate the association of seed yield with other traits at College of Horticulture, UHS campus, GKVK, Bengaluru, using Randomized Complete Block Design replicated thrice. Seed yield per plant recorded significant and positive association with number of umbels per plant (0.906 and 0.845), number of umbellets per umbel (0.902 and 0.727), harvest index (0.849 and 0.588), dry weight of plant (0.765 and 0.689), number of seeds per umbellet (0.704 and 0.516), test weight (0.665 and 0.595) number of primary branches per plant (0.589 and 0.525) and plant height (0.461 and 0.413) at both genotypic and phenotypic levels respectively. The perusal of path analysis revealed that, the characters such as number of primary branches per plant (0.893) and number of umbellets per umbel (0.491) recorded highest positive direct effect on seed yield per plant followed by number of umbels per plant (0.256) and harvest index (0.218) indicating direct selection based on these traits will be rewarding in coriander crop improvement.

PP17

Evaluation of coriander (*Coriandrum sativum* L.) varieties for growth, yield and quality under eastern dry zone of Karnataka

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A field experiment was carried out during November 2016 to February 2017 at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, UHS campus, GKVK, Bengaluru. Sixteen coriander varieties were collected from various institutes and evaluated using Randomized Complete Block Design replicated thrice. Significant variation was observed among the varieties for both quantitative and qualitative traits, except number of seeds per umbellet. The maximum plant height (99.45 cm), and plant spread (1470.40 cm^2) were recorded in RCr-446 followed by RCr-475. Number of primary branches per plant (13.65), number of umbels per plant (31.70), number of umbellets per umbel (8.25), dry weight of plant (9.64 g), test weight (19.50 g), seed yield per plant (7.36 g) and seed yield per hectare (14.35 q) were recorded in (CO(Cr)-4) followed by ACr-1 and RCr-446. Early flowering (38.50 days) was noticed in RCr-446. The maximum essential oil content was recorded in CO(Cr)-4 (0.66%), CO-3 (0.60%) and RCr-446 (0.53%), while, maximum linalool content was observed in RCr-728 (92.33%) and RCr-480 (89.13%). These varieties exhibited better performance with respect to yield and quality parameters, which may be used in further breeding programmes.

PP18

Studies on physico-chemical, antioxidant activity and sorption behaviour of selected varieties of chilli (*Capsicum annum* L.) powders

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Shelf stable chilli (*Capsicum annumn* L.) powders were prepared from red, big and small green varieties by hypochlorite treatment, tray drying, grinding and sieving. The powders were packed in polyethylene (PE) and metalized polyester polyethylene (MPE) pouches and storage studies were conducted on composition, Hunter colour, antioxidant activity and sorption isotherms. The fresh raw chillies such as red, big and small varieties yielded 12.4%, 7% and 7.9% on processing, respectively. The powders were found to be rich in fiber (12-16%), polyphenols (959-1091 mg/100 g) and ascorbic acid (266-390 mg/100 g). Inhibition of 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical by 50% was observed to be 1.2-1.8 $mgml^{-1}$ of chilli powders. Similarly for ABTS radical, 50% inhibition was found to be at 0.4-5.0 $mgml^{-1}$ concentrations. Moisture sorption isotherm of chilli powders showed that the initial moisture contents were 14.04, 10.87 and 8.45%, which equilibrated at 23, 29 and 29% relative humidity (RH), respectively. Similarly critical moisture contents were 15.39 11.46 and 9.05%, which equilibrated at 30, 32 and 32% RH of red, big and small green chilli powders, respectively. These powders are highly hygroscopic in nature, hence protection from moisture and immediate packaging is required. The results showed that the active compounds and activity reduced during storage in all varieties of chilli powders, irrespective of packaging material. However, the chilli powders packed in MPE pouches showed higher activity and red chilli powder exhibited higher quantities of polyphenols, ascorbic acid and antioxidant activity. The study indicated that chilli powder varieties can be conveniently used in different culinary preparations.

PP19

Performance evaluation of cassia genotypes for yield and quality (*Cinnamomum cassia* L.)

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An experiment was conducted at Horticultural Research Station, Pechiparai during 2002 to 2016 to evaluate the performance of cassia accessions for yield and quality. The experiment was laid out in RBD design with four genotypes along with a local check in line planting. Among the different genotypes, D1 recorded maximum tree height (5.50 m), stem girth (32.88 cm), dry leaf (469.57 kg ha^{-1}) and bark yield (259.42 kg ha^{-1}) compared to local check. The performance of D1 was 39.0 percent higher with respect to leaf yield and 16.0 percent with respect to bark yield than local check. D1 also recorded maximum essential oil content in leaf (1.85%) and bark (2.85%) and low leaf (620.50 mg/kg) and bark (20.50 mg/kg) coumarin contents compared to local check.

PP20

Collection and conservation of *Garcinia gummigutta* var. *papilla* – an endemic taxa of Western Ghats

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During a recent germplasm survey, *Garcinia gummigutta* var. *papilla* was located in the Chooralmala area of Wayanad District, Kerala. The trees were located in the evergreen forest fringes and nearby cardamom plantations. This taxa is polygamodioecious with bisexual and male trees. In an area of three sq. km, four fruiting trees were observed and the trees were found to be prolific in bearing. One male tree was also noticed with flowers in clusters. The trees resemble more or less the cultivated *G. gummigutta* var. *gummigutta*. Flowering starts during February - March and the fruit ripens with the onset of next flowering phase in February - March. The fruits are medium sized and the mature fruit rind is darkgreen in colour unlike the yellow fruit rind of *G. gummigutta.* The fruits are used as a spice in culinary preparations by local people. The seeds are very bold with very thin aril. Peculiar feature of this entity is the ripening of fruits in February - March, making post-harvest processing easier unlike, in *G. gummigutta* which ripens during June. This character makes it a worthy material for domestication as a substitute for Malabar tamarind. The long seed dormancy of more than eight months reduces its chance for natural germination. The seeds from fallen fruits were found to be eaten completely by wild animals which in turn results in poor regeneration under natural habitat. Hence, *exsitu* conservation of the tree is a matter of high importance. The scions collected during the survey were propagated through wedge grafting on *G. gummigutta* var. *gummigutta* and *G. indica* rootstocks with a success rate of 80%. The established grafts were planted in the field. *G. gummigutta* var. *papilla* (Wight) Singh is a new addition to the germplasm repository at ICAR- Indian Institute of Spices Research, Kozhkode. This endemic taxa of Western Ghats has great potential for domestication and for utilization in breeding programmes.

PP21

Variability in yield characters of kokum (*Garcinia indica* Choisy) collections in Karnataka

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Kokum (*Garcinia indica* Choisy) is one of the important underexploited tree spices native to Western Ghats of India. It is well distributed in 'Konkan' region of Maharashtra, Goa, coastal areas of Karnataka, evergreen forests of Assam, Khasi, Jantia hills, West Bengal and Gujarat. The fruit rind is having culinary, pharmaceutical and industrial uses. The present study was conducted to evaluate the germplasm for their yield and quality parameters in Uttar Kannada dist. (Karnataka). About 47 trees of uniform age were selected for the study. Among them GI-36 showed maximum individual fruit weight (87.6 g), fruit girth (5.57 cm), fresh rind weight (33.4 g), number of seeds (7), seed weight (16.6 g), dry weight of rind (4.1 g) and dry weight of seed (3.89 g). Lower values

were recorded for many yield characters in GI-29. The plant GI-36 also recorded maximum pulp weight (33.8 g) per fruit which indicated that this tree is good for higher pulp (juice) and dry rind yield.

PP22

Documentation and assessment of underutilized wild spices and aromatic plant species of Bishnupur District, Manipur

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A survey was carried out in ten different areas of the district of Bishnupur, Manipur, India by interacting with the people about the plants or the plant parts used by them. The key informant methods and focus group discussion methods were followed to collect the information. The collected information revealed that certain plants are used traditionally either alone or in combination with other plants for consumption as well as for medicinal purpose. A total of 56 different species belonging to 21 family and 35 genera was found during the survey. Amongst all, the plant species belonging to the family Zingiberaceae are found to consume the maximum followed by Lamiaceae. The aromatic herbs such as *Cardamine hirsute* Linn., *Eryngium foetidum* Linn., *Houttuynia cordata* Thunb, *Leucas aspera* (Willd.) Link, *Ocimum basilicum* Linn. *Oenanthe javanica* (Blume) DC. etc are normally consumed in raw form. There are still ample numbers of available underutilized wild plant species in this region which could be refocused in near future.

PP23

Lesser known spices of NER of India: The future crops for taste and flavour

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Underexploited spices found in North-eastern region of India is highlighted in this paper for their especial flavour and aroma. *Zanthoxylu marmatum* also known as Sichuan Pepper or *Mukthrubi*isa mouth-numbing spice, used in various meat preparations and as a condiment. There is great scope for exploitation of this species as a spice. *Eryngium foetidum* popularly known as spiny coriander has been grown in the kitchen garden for its similar but stronger taste than common coriander. *Maroinakuppi* (*Alliumodorum*) and Maroinapaki (*Allium hookeri*) are the species from onion family whose leaves are used a substitute of onion and garlic in Manipur for their mixed flavour. *Meitei tilhoumacha* (*Allium ascalonicum* Linn.) forms an integral component of garnishing the indigenous chutney *Morokametpa*, cuisine *Eromba*and also used as a substitute for onion. These *Allium* species are resistant to biotic and abiotic stresses as compared to the commercially cultivated species. *Elsholtziablanda* belonging to Lamiaceae family, is an erect herb found growing in Manipur, commonly known as *Lomba, Ban tulsi* in Assamese and *Jungle tulsi* in Nepali. Dried inflorescence is the economic part used for garnishing and flavouring. *Toning-khok* (*Houttuyniacordata*) is a fishy

odour perennial flowering herb used for flavouring traditional dishes and also serve as a traditional medicine for lowering blood pressure, blood purification and dysentery. It is an important medicinal plant in Chinese medicine. The other important spices include *Phakpai* (*Polygonumposumba*), large cardamom (*Amomum subulatum*), tejpata (*Cinnamomum tamala*) and *Kanghuman* (*Salvia bengalensis*). Under the family Solanaceae, *Dallekhursani* (*Capsicum annuum*) is an important cultivar in Sikkim and *Umorok*or Naga chilli (*Capsicum chinense*), the world's hottest chilli is closely linked to the culture of Northeastern people. In addition to their spicy flavouring properties, they are also used as traditional medicine. However, these spices continue as underexploited owing to lack of awareness of their potential, market demand and knowledge of value addition. These lesser known spices have marvellous potential for enhancing food value and diversification of agriculture system apart from their socio-economic as well as ecological value.

SESSION III a:
NUTRIENT, SOIL, WATER & PLANT HEALTH MANAGEMENT

LEAD LECTURES

Quality planting material strategies for spices production

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Introduction

Spices are high-value and low-volume commodities of commerce. Spices play an important role in the food industry world over. The annual world import of spices is on the increase. It has increased from 2.7 billion US $ in 2000 to 5.8 billion US $ in 2010 with an annual growth rate of 7.8%.

During the period 2005-06 to 2016-17, the import of spices has increased from 121.45 million US $ to 686.78 million US $. Indian spices production also increased commensurate with the growing global demand for spices. The production of spices in the country has increased from 3.8 million tonnes in 2005-06 to 8.2 million tonnes in 2016-17 with annual growth rate of 6.5%. Exports of spices from India increased substantially and have crossed 2 billion US $ during 2011-12. The export earnings showed a spectacular growth during the period from 2005-06 to 2016-17 as the earnings increased from 59.9 million US $ to 2663.30 million US $. However the national productivity of all major spices is much lower than the average potential yield recorded in the crop. e.g. productivity of pepper in India is 463 kg/ha where as in Thailand and in Vietnam it is more than 1500 kg/ha. Productivity of ginger in India is 6.4 tonnes/ha whereas that in China is recorded at 10 tonnes/ha. Similarly, productivity of garlic in India is 5 tonnes/ha, which is of no match with that of China which is in the order of 15 tonnes/ha.

The major reasons identified for the low productivity are the poor coverage of area under high yielding varieties and poor management practices followed besides, the declining land area for agriculture. The poor coverage of area under high yielding varieties is in turn attributed to the non-availability of quality planting materials of improved varieties at the farmers' level.

2. Importance of planting material in spices

Quality planting material is of paramount importance in spice cultivation. Both yield and quality are important for the success of spice cultivation. Hence those varieties which have high yield and have the required intrinsic quality alone succeed. Besides the choice of variety, the health of planting material also plays a role in the productivity of the plant. The quality of the planting material has a special significance, especially in perennial spice crops which have a long juvenile / gestation phase and any mistake committed by the grower in the initial stage, in both the choice and health of the planting material, will result in enormous loss in later stages. Hence genuineness and health of the planting material is the pre-requisite to the success of any spice development initiative.

3. Planting material requirement

The tentative requirement of planting materials for the next five years is given in table 1.

Table 1. Tentative requirement of planting materials for next five years (2017-2022)

a) Perennial spices (planting material no. based) (planting material: nos in lakhs)

Crop	2017-18	2018-19	2019-20	2020-21	2021-22
Pepper*	357.287	364.433	371.721	379.156	386.739
Nutmeg	0.693	0.706	0.721	0.735	0.750
Clove	0.089	0.091	0.093	0.095	0.097
Cinnamon	0.014	0.014	0.014	0.014	0.015
Tamarind	0.978	0.997	1.017	1.037	1.058

**with 2 cuttings per standard*

b) Annual spices (planting material weight basis) - Seed to be replaced @25%.

seed in tonnes

Spices	2017-18	2018-19	2019-20	2020-21	2021-22
Ginger	61100	62322	63569	64840	66137
Turmeric	113185	115449	117757	120113	122515
Chilli	441	450	459	468	477
Garlic	41160	41984	42823	43680	44553
Coriander	1370	1397	1425	1453	1482
Cumin	1195	1218	1243	1268	1293
Fennel	93	95	96	98	100
Fenugreek	556	567	579	590	602

(Note: Projection is based on considering an annual growth rate of 2% in area and replanting of 10% of existing area with improved varieties in black pepper and annual growth rate of 2.0% in area in other crops)

As per the estimates, only 18 to 20% of the seed is replaced in seed spices sector. This should increase substantially to improve both productivity and quality of the seed spices cultivated.

4. Production system

Considering the growing demand of the spices, planting material production programme was the major programme undertaken under the Centrally Sponsored Schemes of the Government of India during the initial Five year plans. These programmes were intensified with higher financial allocation since VIII Plan under Centrally Sponsored Scheme, with the introduction of "Integrated Programme for Development of Spices". The strategy adopted for VIII and IX Plan was to enhance the production of nucleus planting materials of improved varieties of spices at the source station itself, which would be utilized for mass multiplication at the State Agricultural Department farms. Accordingly, large scale multiplication of quality planting materials was taken up with the State Agriculture/Horticulture Departments, State Farming Corporation of India, National Horticulture Research and Development Foundation (NHRDF). These programmes were helpful in creating an indirect impact in production of various spices in the country. However, in the present scenario, with the increased demand in planting materials, it is estimated that only 30 to 40 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.

4.1. Existing infrastructure for planting material production in spices

Production of planting materials is being done both in public and private sectors. There are different agencies, which do multiply plants, however, there is a major concern about the authenticity and quality of plant material supplied under private sector.

a) State Govt. nurseries / Farms

Nurseries have been established by the State Governments to cater to the planting material needs of the farming community depending on the crops commercially cultivated there. These nurseries mainly multiply horticultural and social forestry plants. Spices receive little attention in these nurseries. During the recently concluded National consultative meet on planting material production of ginger & turmeric, none of the states reported having taken up planting material production of ginger and turmeric in the State Government farms. It was conceded that major share of the planting material of ginger and turmeric required in the country are obtained through farmer to farmer exchange.

b) ICAR institutes

Planting material for different spice crops is also being produced by several ICAR institutes like ICAR-Indian Institute of Spices Research, Calicut; ICAR-National Research Centre for Seed Spices, Ajmer, ICAR-Central Institute for Arid Horticulture, Bikaner; ICAR-Central Institute for Sub-Tropical Horticulture, Lucknow; ICAR-Central Institute for Temperate Horticulture, Srinagar *etc*.

c) State Agricultural Universities (SAUs)

Almost all the State Agricultural Universities have their own nurseries / farms for supply of planting materials of spices and plantation crops. These universities through their nurseries arrange for multiplication of released/recommended varieties in spices. However, there is a wide gap in demand and supply of recently released varieties in certain crops.

d) Private nurseries

During the beginning of the Eleventh plan period, the Report of the Working Group on Horticulture stated that there are over 6,000 registered small and medium scale nurseries in the country. Large nurseries were around 100 in the country. No. of nurseries have increased because of the assistance provided by NHM, however, the availability of planting materials of spices is still far below the requirement.

Table 2. Available nurseries in public and private domain for various horticulture crops in the country as recorded in the report of the Working Group on Horticulture for XI Plan

Sl. No.	State	Number of nurseries			Total
		Public sector	SAUs/ICAR institutes	Private sector	
1.	Andhra Pradesh	57	-	913	970
2.	Arunachal Pradesh	20	-	37	57
3.	Assam	4	-	82	86
4.	Bihar	127	27	126	280
5.	Chhattisgarh	106	1	-	107
6.	Goa	-	-	-	-
7.	Gujarat	23	14	335	372
8.	Haryana	25	1	36	62
9.	Himachal Pradesh	78	-	648	726

10.	Jammu & Kashmir	77	-	348	425
11.	Jharkhand	157	2	-	159
12.	Karnataka	28	-	15	43
13.	Kerala	64	26	30	120
14.	Maharashtra	136	42	1,300	1478
15.	Madhya Pradesh	270	-	-	270
16.	Manipur	12	-	41	53
17.	Meghalaya	31	-	-	31
18.	Mizoram	9	-	8	17
19.	Nagaland	2	-	15	17
20.	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

4.2 Nurseries established under NHM/MIDH

Based on the recommendations of the Core Group, National Horticulture Mission, which was launched during 2005-06, gave focused attention to the production of good quality planting materials of horticulture crops and efforts were made to create necessary infrastructure in the form of nurseries like model nursery, hi-tech nursery, small nursery and upgradation of existing nurseries *etc.* During the period from 2005-06 to 2015-16, 4524 nurseries were established in various states to ensure the availability of quality planting materials.

Table 3. Nurseries established under NHM

S. No.	State	No. of nurseries established
1	Andaman & Nicobar	30
2	Andhra Pradesh	153
3	Bihar	90
4	Chhattisgarh	158
5	Delhi	10
6	Goa	9
7	Gujarat	69
8	Haryana	63
9	Jharkhand	145
10	Karnataka	487
11	Kerala	327
12	Madhya Pradesh	192
13	Maharashtra	151
14	Orissa	227
15	Pondicherry	4
16	Punjab	5
17	Rajasthan	135
18	Tamil Nadu	199
19	Telangana	0

20	Uttar Pradesh	176
21	West Bengal	151
22	Arunachal Pradesh	129
23	Assam	165
24	Manipur	70
25	Meghalaya	256
26	Mizoram	41
27	Nagaland	190
28	Sikkim	210
29	Tripura	229
30	Himachal Pradesh	103
31	Jand K	246
32	Uttarakhand	104
	Total	4524

Source: www.nhm.nic.in

4.3 Planting material production under NHM/MIDH

With the launch of National Horticulture Mission 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 whole demand of planting material through public domain alone, it was found necessary to encourage private participation in the sector. To ensure that only quality planting material reach the farmers it was found necessary that a uniform regulatory mechanism should be established in the country.

The MIDH gave top priority to the production and distribution of good quality planting materials of horticulture crops including spices. To meet the requirement of planting materials (for bringing additional area under improved varieties of horticultural crops and for rejuvenation programme for old / senile plantations), assistance is provided for setting up new hi-tech nurseries and small nurseries under the public as well as private sector. Assistance is also provided for upgradation of existing nurseries. The MIDH also supports planting material production of spices.

a) Hi-tech nurseries

Hi-tech nurseries will have an area between 1to 4 ha with a capacity to produce 50000 plants per ha of mandated crops. The plants produced will be certified for the quality. The infrastructure support includes proper fencing, scion / mother block of improved varieties, root stock block, net house, irrigation facilities, hi-tech green house having insect proof netting on sides and fogging and misting systems, hardening / maintenance in insect proof net house with light screening properties and sprinkler irrigation system, pump house to provide sufficient irrigation to the plants and water storage tank to meet at least 2 days requirement and soil solarisation –steam sterilization system with boilers. Rate of assistance for establishing Hi-tech nursery is Rs 25 lakh/ha. 100% assistance is provided for public sector. For private sector, credit linked back ended subsidy @ 40% of cost, subject to a maximum of Rs 40 lakh/unit, for a maximum of 4 ha will be provided.

b) Small nurseries

Small nurseries with an area up to one ha will have provision for naturally ventilated green houses and net houses. Small nurseries need to produce 25000 plants of the mandated perennial vegetative propagated plants per year, duly certified for its quality. Nurseries will also be regulated under legislation in force relating to seeds and planting material. Efforts will be made to establish nurseries at production cluster itself. Nurseries will be encouraged to go in for accreditation. Planting material for MIDH programme will be procured only from accredited nurseries. Rate of assistance for establishing small nursery is Rs 15 lakh/ha.100% cost is provided for public sector. For private sector, credit linked back -ended subsidy, subject to a maximum of Rs 7.5 lakh/unit.

c) Upgrading nursery infrastructure to meet accreditation norms

Nurseries in the public and private sector can avail assistance to upgrade nursery infrastructure to meet accredited norms. Rs 10 lakhs is provided to nurseries in the public sector and 50% of the cost (Rs 5 lakhs) is provided to the nurseries in the private sector for upgradation. The infrastructure facilities will include establishment of hot bed sterilization of media, working shed, virus indexing facility, hardening chamber/net house, mist chamber, establishment of mother block, irrigation and fertigation facility/ unit.

d) Seed production for vegetable and spices

Estimated cost of seed production of vegetable and spices (seed spices and chillies) are Rs 35000/ha for open pollinated crops and Rs 1.50 lakhs per ha for hybrid seeds. Assistance is provided @100% of total cost to public sector. In the case of private sector, assistance is 50% of cost as back ended subsidy. Assistance is available for a maximum are area of 5 ha per beneficiary.

e) Production and distribution of nucleus planting materials

Under NHM/MIDH, various State Governments have been assigned with programmes for area expansion, high yielding variety coverage, rejuvenation etc., requiring sizeable quantity of quality planting materials of the respective 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, including building up the required facilities in the research farms attached to the State Agricultural Universities, ICAR institutes *etc*. All the selected spices crops under NHM programmes assigned to the State Governments are included.

5. 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.
- Lack of effective disease and pest management in commercial nurseries.

- Non existence of virus-indexing 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.

6. Accreditation of spices nurseries

The planting material requirement of the spices growers is mainly met by nurseries established under State Department of Horticulture/Agriculture, the SAUs and ICAR institutes at present. However, these nurseries in public domain provide only 30-40% of the demand for planting material. The major part of the demand is met by the unregulated private nurseries, which lacks modern infrastructure such as green house, mist chamber, efficient nursery tools and gadget, implements and machinery. Accreditation of nursery is an important step to regulate the quality of planting materials supplied by these nurseries.

6.1. Accredited nurseries

During the Eleventh Plan period, National Horticulture Board started programme on accreditation of nurseries with the aim to improve quality of planting materials being supplied to the farmers. As per NHB website, at present there are more than 1500 accredited nurseries in fruits, plantation crops and spices, the ones catering the spices sector are only 26 numbers, details of which are given in table below.

Table 4. No. of accredited nurseries in spices sector

Spice	No. of accredited nursery	State	Production capacity (no.)
Pepper	17	Karnataka (12), Kerala (2), Maharashtra (2), Tamil Nadu (1)	22,60,000
Cinnamon	2	Maharashtra (2)	10,200
Nutmeg	7	Karnataka – 1 Kerala – 5 Maharashtra - 1	3,23,120

From 2014-15 DASD has been authorized by the Ministry of Agriculture and Farmers Welfare, Govt of India for accrediting spices nurseries. Accreditation of nurseries is an important step to ensure availability of quality planting material to the farmers. As per the MIDH norms, planting materials need to be procured only from accredited nurseries for all government programmes.

The three important aspects to define a model nursery in a comprehensive manner are a) The nursery infrastructure; b) Quality parameter of planting material adopted; and c) Adoption of good nursery management practices. A recognized model nursery should function as a reliable source of supply of quality planting material for spice crops.

With a view to ensure availability of Good Quality planting material as outlined above, DASD has started a system of accreditation of spice nurseries. About 25 nurseries are recognised under DASD accreditation programme. Accredited nurseries will be displayed in the website of the Directorate for the knowledge of the farmers.

6.2. The nursery infrastructure

6.2.1. Different features of a model nursery

a) **Mother blocks** – Consists of the *elite* plants of the recommended varieties, closely planted and managed for regular supply of scion shoots/shoots for propagation.
b) **Poly house** – A structure created with the help of polyethylene sheets with humidity and temperature control mechanism primarily used for keeping freshly grafted /budded plants so as to get early union and high success rate.
c) **Shade net** – Simple Structure stretched for providing partial shade to mother plants and for keeping young plants for hardening. Shade net also gives protection against frost and hailstorm. etc.
d) **Net house -** Insect proof structure stretched over mother plants/newly propagated plants to avoid insect attack and viral contamination
e) **Wind breaks –** A group of fast growing fruit and forest plants which are raised along the boundaries of the field. Such grown up trees can minimize the wind velocity and to some extent can reduce the level of harshness during the extreme conditions of high band low temperature.

6.3. Quality parameters of planting material adopted

It is important that the plant propagule attains the required growth before it is planted in the field. The standards for planting material of different spice crops are given below

Table 5. Standards for planting material

Crop	Standards for planting material
Black pepper	1. The planting material for multiplication should be produced from the mother plant of seven years and above, a stable yielder and free from pest diseases. 2. The age of the rooted cutting should be 21/2 months old (15-20 cm height) from the date of planting in the polythene bags. 3. A minimum of five leaves should be present with vigorous growth without exhibiting any nutrient deficiency symptoms 4. Profusely developed roots with the absence of *Phytophthora capsici* spores and nematodes/virus infection /scale/mite/thrips/mealy bugs on the cuttings. 5. Varietal purity.
Cardamom	1. In the case of seed propagation, the capsule should be bold, healthy, uniform with high germination percentage. 2. The age of the suckers/slips must be 9-10 months at the time of distribution 3. A minimum of 5-7 leaves and height of 60-75 cms should be present with vigorous growth 4. Absence of katte virus/clump rot/kokke kandu /fungal diseased or insect infested suckers 5. Varietal purity.
Clove	1. Height of seedlings should be 50 cm (9-24 months depending upon management) 2. Absence of disease/pest infestation
Cinnamon	1. One year old bagged cuttings must be used for planting 2. Minimum height should be 25 to 30 cm 3. Absence of disease/pest infestation

Ginger	1. Seed material should be healthy and plumpy in appearance. 2. Scales and mealy bugs infestation and dry rot infection in rhizomes must be less than 1-5% 3. Varietal purity 4. Germination must be 95-98%
Turmeric	1. Seed material should be healthy and plumpy in appearance. 2. Scales and Mealy bugs infestation and dry rot infection in rhizomes must be less than 1-5% 3. Varietal purity 4. Germination must be 95-98%
Nutmeg (grafts)	1. Vigorously growing plant with a height of -15 cm 2. Height and condition of the union - > 15 cm, strongly united. 3. Scion and shoot diameters at the union - > 0.6 cm and above 4. Well developed tap root system. 5. Absence of dieback or shot hole symptoms

6.3.1. Seed standards in seed spices

The prescribed permitted seed standard limits of seed spices crops are given in table 6.

Table 6. Seed standards for seed spices

Name of the crop	**Seed standard (%)**											
	Pure seed (minimum)		Inert matter (maximum)		Seed of other crop (maximum)		Total weed Seed (maximum)		Germination (%)		Moisture (%)	
	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS	FS	CS
Coriander	98	97	2	3	0.10	0.20	0.10	0.20	65	65	10	10
Cumin	95	95	5	5	0.05	0.10	0.10	0.20	65	65	8	8
Fennel	95	95	5	5	0.05	0.10	0.10	0.20	70	70	8	8
Fenugreek	98	98	2	2	0.10	0.20	0.10	0.20	70	70	8	8
Ajowain	95	95	5	5	0.05	0.10	0.10	0.20	65	65	8	8
Dill	95	95	5	5	0.05	0.10	0.10	0.20	70	70	8	8

FS - Foundation Seed; CS - Certified Seed
Note: Insect damaged seeds should not be more than 0.5% in each sample.

6.4. Adoption of good nursery management practices

The three most important aspects in planting material production are:

1. Making available improved varieties of spices released in sufficient extent.
2. Adoption of appropriate propagation techniques
3. Technology for making available quality disease-free planting materials

6.4.1. Making available improved varieties of spices released by research stations in sufficient quantity

a) Prominent high yielding and improved varieties of spices available in the country

Black pepper:- Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Panniyur-6, Panniyur-7, Panniyur – 8, Subhakara, Sreekara, Karimunda, Panchami, Pournami, Kottanadan, IISR Thevam , IISR Shakti, Vijay *etc*.

Ginger:- Suprabha, Suruchi, Surabhi, Himagiri, IISR-Varada, IISR-Rejatha, IISR-Mahima, Maran, Rio de Janeiro, Himachal, Valluvanad, Kuruppampady, Aswathy, Karthika, Aathira, Nadia *etc*.

Turmeric:-CO- 11983, BSR-11986, BSR-21994, Roma, Suroma, Ranga, Rasmi, Rajendra Sonia, Megha Turmeric -1, Pant Peethabh, Suranjana, Duggirala, Alleppey Supreme, IISR Kedaram, Suvarna, Suguna, Sudarshana, IISR Prabha, IISR Prathibha, Kanthi, Sobha, Sona, Varna,Narendra Haldi 1 *etc*.

Chilli:- K-1, K2, Co-1, , Pusa Jwala, Pusa Sada Bahar, NP 46A, Capsicum – Pusa Deepti, KDC-1, Pant C-1, Pant –C2, Kalyan Sel.1, G1-1962, G2 -1962, G3-1962, Bhagya Laxmi, LCA-305, LCA 334, LCA 235, LCA 353, Punjab Lal, CH-1, CH-2, CH-3, Arka Harita, Arka Lohit, Arka Meghana, Jwalasakhi, Jwalamukhi, Ujjhala, Anugraha, KA-2, Hisar Shakthi, Hisar Vijay. **Garlic**:- Agrifound white, Yamina safed-1, Yamuna safed -2, Yamuna safed-3, Agrifound Parvati, G-323, Pant Lohit-1, Pant Lohit-2, Pusa Sel-10, HG-1, HG-6.

Cinnamon:- IISR-Nithyashree, IISR-Navashree, YCD-1, PPI(C)1, Konkan Tej, Sugandhini, RRL (B), *etc*.

Nutmeg:- Konkan Sugandha, Konkan Swad, Viswashree, Keralashree.

Tamarind:- PKM_1, DTS-1, Prathisthan, NO.263, Yogeswari

Curry leaf:- DWA-1, DWA-2, Suvasini

Coriander:-Guj. Cor.1, Guj. Cor.2, Co.1, Co.2, Co.3, Rajendra Swati, RCr.41, RCr.20, RCr.435, RCr.436, RCr.446, Sadhana, Swathi, Hisar Sugandh, Hisar Anand, Pant Haritima, Azad Dhania–1 *etc.*

Cumin:- MC 43, Guj Cumin 1, Guj. Cumin 2, Guj. Cumin-3, Guj. Cumin-4, RZ 19, RZ-209, RZ-223 etc.

Fennel:- Guj. Fennel 1, Guj. Fennel-2, Co-1, RF-101, RF-125, Hisar Swarup, Azad Sauf – 1, Pant Madhurika, Rajendra Sourabha *etc.*

Fenugreek:- Co.1, Co.2, Rajendra Kanti, Rajendra Abha, Hisar Sonali, Hisar Suvarna, Hisar Guj. Neethi, RMt.1, RMt – 143, RMt-303, RMt-305, Rajendra Khushba, Pusa early bunching,

Ajowan:- Gujarat Ajowan -1, Pant Ruchika, RPA-68, Ajmer Ajowan -1, Ajmer Ajowan -2, Lamsel-1, Lamsel-2, Rajendra Mani.

Celery:- RRL-85-1

Dill:- Guj. Dill-1, Guj. Dill-2, RSP-11, Ajmer Dill -1, Ajmer Dill-11

6.4.2. Adoption of appropriate propagation techniques

Shortage of quality planting material is the major bottleneck in the production of Spices. There is immense scope in the employment and income generation through production and supply of quality planting material of spices. But lack of awareness and technical know - how for production of quality planting material hampers spices production. Hence, farmers need to adopt appropriate production techniques for planting material production.

In case of black pepper serpentine method, raising of shoots on inclined bamboo stick are popular in the planting material production. Protray technique in ginger and turmeric is being popularized for the production of healthy planting material production. Different types of vegetative propagation methods are recommended for tree spices.

Table 7. Propagation techniques

Spices	Propagation Techniques
Black pepper	*In situ* planting, raising of rooted cuttings in poly bags, rapid multiplication method or bamboo method, serpentine method
Ginger and turmeric	Protray technique, rhizome propagation
Chilli	Raising of seedlings
Nutmeg	Seed Propagation, epicotyl grafting and budding
Cinnamon	Seed propagation ,cuttings, and air layering
Clove	Raising of seedlings
Garlic	Cloves or bulbils
Seed spices	Raising of seedlings

6.4.3. Technology for making available quality disease-free planting materials

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.

In the absence of high degree of host resistance for many of the soil borne plant pathogens, it becomes imperative to give a major thrust on an effective disease management which starts right from nursery stage. Over years, the microbial technology suppressive to soil borne plant pathogens in spices have been developed which becomes handy to implement. These microbials need to be exploited to ensure protection from root infection.

a) Soil disinfection of the nursery mixture

Soil disinfection through fumigants or through complete soil sterilization becomes difficult because of high energy costs involved. However, soil 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.

b) Incorporation of bio-control inoculums into the nursery mixture

Soil solarisation combined with microbial inoculumwhich 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), antogonists like *Trichoderma* spp., *Psuedomonas* spp., *Bacillus* spp. have been extensively used for the nursery programmes as well as for field management of the disease. *Glomus fasciculatum* is one VAM fungus which has been extensively investigated and was found effective in protecting the root system against *Phytophthora capsici, Radopholus similis* and *Meloidogyne incognita*. Incorporation of VAM inoculum into the nursery mixture (either solarized or non solarised) prior to planting would ensure greater protection of the root system, leading to production of disease free planting material.

c) Fungal antagonists / hyperparasites

Fungal antagonists like *Trichoderma harzianum*, *Trichoderma viride* have been amply demonstrated to be highly effective in checking the soil borne infections. This has been well established for control of soil borne pathogens in the case of black pepper, cardamom, ginger, turmeric ,cumin, coriander and fenugreek. As such, it is recommended to incorporate these bio innoculants into the nursery mixture.

Similarly, *Pseudomonas fluorescens*, *Bacillus subtilis* and Plant Growth Promoting Rhizobacteria (PGPR) are the other important bacterial antagonists which are found effective against soil borne problems. These also can be incorporated into the nursery mixture. These PGPRs not only ensure protection from the soil borne pathogens but also ensure plant growth and induced systemic resistance that would ensure health of the planting material.

d) Seed disinfection

In the case of black pepper, mother vines should be selected only from a uniformly established gardens free from diseases and pest. These selected vines should be monitored at least once in a year for a possible infection of the disease and continuously monitored for future use.

In the case of ginger and turmeric, the soil borne plant pathogens *viz*., *Ralstonia solanacearum*, *Pythium aphanidermatum*, *Pratylenchus coffeae* 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 inoculants (bio control agents). In Sikkim, seed treatment of ginger seed rhizomes at 51^0C 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.

e) 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.

f) Micropropagation (tissue culture) as a strategy for production of healthy planting material

Biotechnological method of plant propagation called as micropropagation through tissue culture technique is in vogue for several horticulture crops. Protocols for micropropagation of spices have been standardized. The biggest advantage of tissue cultured black pepper cuttings is total elimination of all the major pathogens, if one selects explants from high yielding mother vines totally free from virus diseases (CMV and 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.

The biggest constraint identified in planting material production of ginger is the prevalence of diseases like soft rot diseases (both fungal and bacterial), *Bellakedu* disease and pests like shoot borer rhizome maggot *etc*. Soft rot of ginger is very rampant and is one reason due to which farmers hesitate to take up the cultivation in large scale. Production of disease free planting material in ginger can reduce the risk of total crop loss and the period of rotation of the crop in the field. The micro-tuber production technology in ginger can ensure 100% elimination of pathogen from the seed material. This technology is successful with ginger, and is being tried for commercial application.

The micro and mini rhizomes so raised in the labs can be grown and multiplied under protected condition in poly houses in soil-less culture medium to ensure that the seed rhizome continues to be disease free. However, the cultural practices for poly house cultivation need to be fine tuned for ginger crop.

7. Conclusion

National Horticulture Mission had originally aimed at doubling the production of horticulture crops by the XI Plan period, primarily through improvement in productivity of the crops. To achieve this task, availability of healthy planting materials of improved varieties takes the centre stage of all developmental activities. As per the reports available from NHM/MIDH, around 2939 nurseries including small, model and hi-tech nurseries under public / private sector have been set up across the country under NHM. The Directorate of Arecanut and Spices Development has been supplementing these efforts by implementing programmes on nucleus planting materials through various 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, which will pave the way for the development of spice Industry in the country in a sustainable way.

Plant health management vital for spices development in North Eastern Region

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Introduction

Horticultural crops occupy a unique role in developing countries both in economic and social spheres in respect of improving income and nutritional status particularly of rural masses. India, reckoned as "Spice Bowl of the World" adorns a formidable position in the global spice scenario. Unlike other countries, in India, spices are grown as mixed crop in homestead gardens, coffee, tea, arecanut and coconut plantations. While, spices like ginger, turmeric, chilli and seed spices are cultivated in rotation with pulses and other field crops. India grows over 50 spice crops and chilli, black pepper, cardamom, ginger, turmeric and a variety of seed spices are the major ones cultivated on a commercial scale. The diverse agro-climatic conditions of India are ideally suited for diversification of spices amidst a cascade of bottlenecks in production and marketing chain. In order to compete with other spice growing nations across the globe and to capture a leading position in the world spice market it is indispensible to tap the inherent potentiality of non-conventional spice growing regions through area expansion and prop up the production of high quality produce in consonance with food safety standards.

The North Eastern Region (NER) of India in general and northeastern hilly region in particular is highly exclusive in nature due to its peculiarities of location, terrain characteristics, climatic patterns and ecological biodiversity. The NER spans an area of 2,62,180 square kilometers, which is virtually 8% of the total geographic area of the country. The agricultural production system in the region is predominantly rainfed (mean annual rainfall exceeding 2000 mm), mono-cropped at subsistence level. The agricultural production system is characterized by and large CDR (complex diverse risk prone) type, low cropping intensity, subsistence farming, undulating topography and faulty land use pattern. The soils are rich in organic matter and acidic to strongly acidic and thus ideal for cultivating variety of spices. The average size of operational holdings is found to be lower in NER as compared to the same at the all-India level. The cropping pattern in the region (except Sikkim) is characterized by predominance of rice as the lead crop; however, maize is the dominant crop in Sikkim. But the existing data and literature suggest that in spite of certain favourable conditions prevailing in the region for a prosperous agriculture, productivity of major crops has remained at a low level in most of the states of the region.

Under this low investment-low-income farming situation, probably horticulture sector has desirable attributes to accelerate the agricultural growth process in the region. Ginger, turmeric, large cardamom and black pepper are the important spices cultivated in NER (fig. 1). However, considering the acreage under different spices, ginger is the major cash crop supporting livelihood and improving the economic status farmers of NER. Ginger holds a dominant position in all states of the region of which Meghalaya, Mizoram, Arunachal Pradesh and Sikkim contribute the lion share in production and productivity. Ginger is followed by large cardamom, turmeric and black pepper and there is a great prospect for other commercial spices like vanilla, cumin and saffron. The NER, often branded as 'default organic' has the immense potential of offering the safest produce in the regime of pesticide abuse and residues.

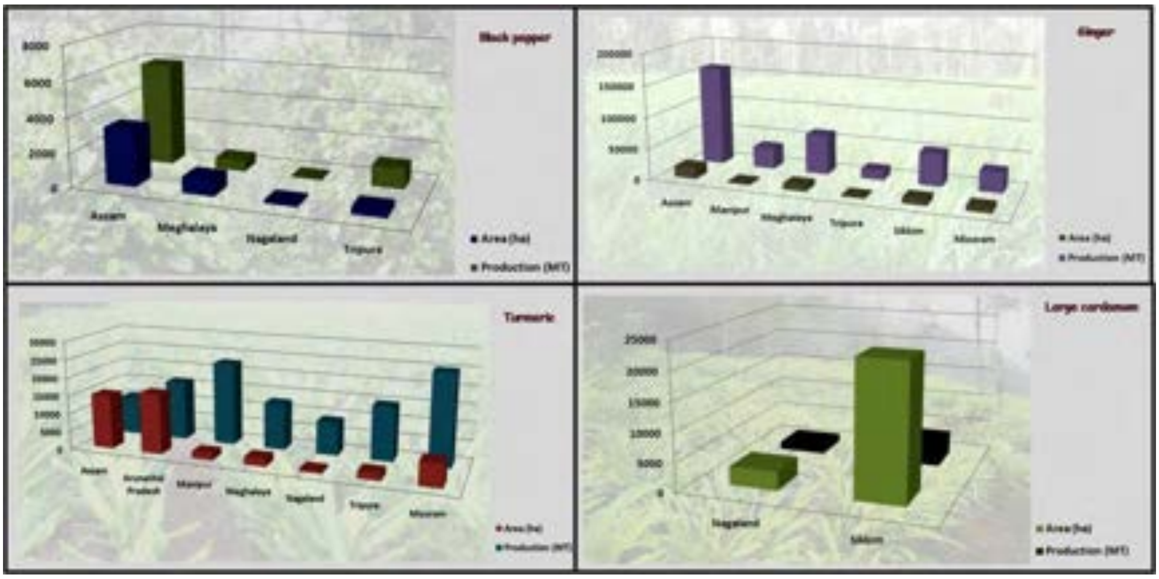

Fig. 1. Area and production of major spice crops in North Eastern States

Production constraints and bridging knowledge gaps

The NER, though endowed with congenial natural environment to sustain a plethora of spice crops, is also plagued with several climatic, geographic and socio-economic issues that hamper agricultural production of the region. Low and uncertain agricultural productivity due to vulnerability to flood, drought, soil erosion, lack of market opportunities and remoteness, low usage of growth augmenting inputs such as a irrigation, quality planting material, biological and chemical inputs undoubtedly contributed to the dismal performance and low income, a precursor of agrarian crisis.

Successful cultivation of spices is limited by heavy crop losses caused by diseases, nematodes and insect pests. *Phytophthora, Pythium, Rhizoctonia, Colletotrichum* and *Fusarium* are the pathogens of major concern in these spices. Among the bacterial diseases, wilt in ginger incited by *Ralstonia solanacearum* Biovar 3 continues to be the most important production constraint in tropical, sub-tropical and warm temperature regions of the world. Diseases incited by viruses in black pepper and large cardamom are one among the bottle necks in realizing appreciable yield levels as they are primarily spread through infected planting material with a potential to transform the healthy plantation to a senile condition within a short span of time. Pests like shoot borer (*Conogethes punctiferalis*) and secondary pests like maggots are real problems in ginger and turmeric. Among nematodes, *Meloidogyne incognita* (root knot nematode) and *Radopholus similis* (burrowing nematode) occur on black pepper, turmeric and ginger. A brief description of the major production constraints encountered in production of spices with respect to the crops cultivated is given below.

Black pepper

Foot rot

In nurseries, foliar symptoms appear as black lesions with fimbriate margins subsequently leading to defoliation. Under field conditions, the disease initiates as black spots on foliage with characteristic fimbriations along advancing margins. The tender leaves and succulent shoot tips of runner shoots trailing on soil turn black when infected. Infection at collar region results in wilting of entire vine followed by shedding of leaves and spikes. If the damage is confined to the feeder roots, expression of symptoms is delayed till monsoon recedes during which the vine exhibits declining symptoms such as yellowing, defoliation and drying. The disease is caused by *Phytophthora* spp.

Slow decline

The symptoms initiate as mild to moderate foliar yellowing, which is more pronounced during summer season. Later, the infected vine defoliates and exhibits dieback, loss of vigour leading to death of the vine. Gradual decline and foliar yellowing are the predominant symptoms induced by root knot nematode, *Meloidogyne* sp. Such vines exhibit dense interveinal chlorosis with formation of galls or knots on secondary and fibrous roots and as elongated swellings on thick primary roots. Foliar yellowing and defoliation are the major aerial symptoms induced by *R. similis*. Root penetration by *R. similis* causes necrotic lesion on feeder roots.

Anthracnose/spike shedding/fungal pollu

The initial symptoms appear as small necrotic spots surrounded by yellow halo on foliage. In severe cases, laminar expansion is affected, resulting in crinkled appearance and defoliation. Infection on spikes results in spike shedding whereas, infection on mature berries leads to formation of brownish splits due to unequal development. In later stages, the discolouration gradually increases and the berries exhibits characteristic cross splitting. The disease is caused by *Colletotrichum* spp.

Stunt disease

Mosaic, mottling, leaf deformation and stunting are the common visible symptoms induced by viruses. The initial symptoms include formation of chlorotic specks, vein clearing, mosaic and yellow mottling. Severe symptoms develop sporadically on flushes of new growth, while mature leaves exhibits milder symptoms or remain symptomless. The infected vine produces short spikes with poor filling. In severe cases, the leaves become abnormally narrow and appear sickle shaped. The internodes of vines become abnormally short leading to stunting of plants and affected branches give a typical witches broom appearance in advanced stages. The disease is caused by *Cucumber mosaic virus* (CMV) and *Piper yellow mottle virus* (PYMoV). The major means of spread is through infected planting materials. CMV could also be transmitted mechanically to several cucurbitaceous and solanaceous hosts. On contrary, PYMoV has narrow host range and transmitted semi persistently by mealy bugs such as *Ferrisia virgata* and also through seeds.

Scale insects

The mussel scale (*Lepidosaphes piperis*) and coconut scale (*Aspidiotus destructor*) causes damage to black pepper vines especially at higher altitudes. The infestation is severe during the post monsoon and summer periods. Scale insects are sedentary, remain permanently adhered to the plant parts and appear as encrustations. They feed plant sap and cause yellowing and wilting of infested portions and in severe cases, the affected portions of vines dry up.

Mealy bugs

Among the different species of mealy bugs infesting black pepper, *Planococcus* spp. (*P. citri* and *P. minor*) and *Ferrisia virgata* are common in occurrence. Mealy bugs are sap-feeding insects and the adult females are covered with white cottony wax secretions that resemble tiny cotton balls. The combined damage by root mealy bugs in association with *Phytophthora* and plant parasitic nematodes hastens decline of the vine. In addition to inflicting direct damage to the vines as sap feeders, *F. virgata* also acts as a vector of *Piper yellow mottle virus* (PYMoV), a major viral pathogen of black pepper. The infestation by mealy bugs is noticed throughout the year, however it attains severity during post - monsoon period *i.e.*, from October onwards.

Ginger

Soft rot

Soft rot caused by *Pythium* spp. results in foliar yellowing which initiates from leaf tip and spreads downward along the margins leading to death of leaves, which droop and hang until the entire shoot dries. The basal portion exhibits pale translucent discolouration, which later turns water soaked and soft leading to toppling of affected shoots. The rhizomes initially turn brown, gradually decompose transforming into a watery mass of putrefying tissue enclosed within skin of the rhizome emitting foul smell.

Fusarium yellow

The symptoms caused by *Fusarium oxysporum* f. sp. z*ingiberi* initiates as marginal yellowing of lower leaves, which gradually spreads to entire leaf lamina. The mature leaves dry initially, followed by the younger ones. Other pronounced symptoms include, premature drooping, wilting and drying in patches.

Leaf spot

Leaf spot disease is caused by Phyllosticta zingiberi and Colletotrichum zingiberi, of which the former is the major one. The symptoms include formation of small, spindle to oval or elongated spots with white papery center and dark brown margins surrounded by yellowish halo. The infected areas often dry up at the center, forming shot holes and subsequently, the entire leaf dries. The disease appears towards end of June when the plants are at the most susceptible stage (3-4 leaf stage). Later in July, when the number of rainy days and total rainfall increases, the disease aggravates and spreads at faster rate. Ginger up to the age of 6-7 months are susceptible to the disease and two weeks old leaves are most susceptible.

Bacterial wilt

Bacterial wilt caused by *Ralstonia solanacearum* Biovar 3, is one of the important rhizome-borne diseases of ginger. The first noticeable symptom of bacterial wilt is downward curling of leaves due to loss of turgidity. The leaves droop and wilt leading to death of above ground parts. The affected rhizome starts rotting and emits foul smell. Rhizome-borne inoculum is primarily responsible for disease initiation and the pathogen survives in soil, which makes it unsuitable for ginger cultivation once introduced through infected planting material.

Storage rot

The rot induced by different fungi during storage of the harvested produce adversely affects the quality of seed rhizomes and its germinability. The fungi representing the genera, *Fusarium* and *Macrophomina* incites rotting of the rhizomes while storage.

Nematodes

Root knot (*Meloidogyne* spp.), burrowing (*Radopholus similis*) and lesion (*Pratylenchus* spp.) are important nematode pests of ginger. The symptoms induced by nematodes include stunting, chlorosis and failure to tiller profusely. Characteristic galls and lesions on roots that lead to rotting are generally observed.

Shootborer

The shoot borer (*Conogethes punctiferalis*) is the major insect pest of ginger. The larvae bore into pseudostems, feed on internal tissues leading to yellowing and drying of leaves. The presence of a bore-hole on the pseudostem through which frass is extruded and the withered and yellow central shoot is a characteristic symptom of pest infestation. The pest population is higher during September-October.

Rhizome scale

The rhizome scale (*Aspidiella hartii*) infests rhizomes at later stages in the field and in storage. Adult (female) scales are light brown to grey and appear as encrustations on the rhizomes. They inflict damage by feeding sap and severely infested rhizomes appear shriveled and desiccated leading to poor germination.

Turmeric

Rhizome rot

The collar region of the pseudostem becomes soft and water soaked, resulting in collapse of the plant and decay of rhizomes. The disease is caused by *Pythium graminicolum* and *P. aphanidermatum*. However, the predominant species associated with rhizome rot of turmeric is *P. aphanidermatu*m.

Leaf blotch

The disease initiates as small, oval, rectangular or irregular brown spots on either side of the leaves which soon become yellowish or dark brown. The leaves also turn yellow. In severe cases the plants present a scorched appearance and rhizome yield is reduced significantly. The disease is caused by *Taphrina maculans.*

Leaf spot

The disease appears as brown spots of various sizes on the upper surface of young leaves. The spots are irregular in shape with white or grey center. Later, two or more spots may coalesce and form an irregular patch spreading entire leaf. The affected leaves eventually dry up. Leaf spot is caused by *Colletotrichum capsici*.

Nematodes

Root knot (*Meloidogyne* spp.) and burrowing nematode (*Radopholus similis*) are the two important nematode genera infecting turmeric. Root lesion nematodes (*Pratylenchus* spp.) are of common occurrence in Andhra Pradesh.

Large cardamom

Leaf streak (Pestalotiopsis royenae and P. versicolor)

Leaf streak is characterized by the formation of numerous translucent streaks on young leaves which proliferates along the veins which later turn reddish-brown with a central straw coloured necrotic area surrounded by dark brown margins. Later, these spots coalesce to give a blighted appearance to the foliage which withers off during the rainy season.

Chirke or mosaic

Chirke is characterized by mosaic streaks on the leaves which gradually coalesce and eventually turn brownish and dry up. The flowering in affected plants is severely affected leading to heavy yield reduction. The disease is caused by *Large cardamom chirke virus* (LCCV) of the family Potyviridae. The virus is transmitted by aphid vectors *viz.*, *Ropalosiphum maidis*, *R. padi*, *Brachycaudus helichrisi* and *Silobion aveneae*. The disease is not transmitted through seed or soil but it is readily transmitted through infected rhizomes as well as by sap inoculation method.

Foorkey

The disease is characterized by dwarf tillers with small and slightly curled pale green leaves. The infected plants produce dwarf tillers, sterile shoots, subsequently leading to stunted growth of shoots which fails to produce flowers. In advanced stages, the inflorescences are transformed into leafy vegetative parts and as a consequence fruit formation is completely suppressed. The disease is caused by *Cardamom bushy dwarf virus* (CBDV) representing Nanoviridae. The disease is spread by the aphids, *Pentalonia nigronervosa* and *Micromyzus kalimpongensis*. The disease is not sap transmissible and long distance primary spread is mainly through the infected rhizomes.

Leaf eating caterpillar and aphids

The leaf eating caterpillar (*Artona chorista*) and banana aphid (*Pentalonia caladii*) are the major insect pests of large cardamom. The caterpillar feeds on the leaf lamina subsequently leading to defoliation leaving the midribs. The aphids suck sap thereby adversely affecting plant vigour. Besides directly inflicting damage, they act as vectors of viruses causing *Foorkey* and *Chirke* diseases.

Plant health management

Plant health management is the science and practice of understanding and eliminating the succession of biotic and abiotic factors that limit plants from achieving their full genetic potential. It is much broader than integrated pest management and it involves all activities on that focus on the prevention, monitoring, and management of pests and diseases. Plant health is intimately linked to the health of the agroecosystem in which the plant flourishes. There is every possibility that intensification of agricultural production to meet growing food demand often increases application of inappropriate practices, which may spoil the pristine environment of NER.

Planting materials do matter: Crop diversification and intensification means introduction of planting materials in bulk quantities, which can be a potential threat to the biosecurity of the region. Extreme care should be taken to introduce certified, elite genotypes that are free healthy in all respects. Being vegetatively propagated, *in situ* production of disease-free quality planting material of promising varieties will be a better option than introducing bulk quantities of planting materials from other states. In such a scenario, indexing of mother stock with sensitive tools, especially for the cryptic viruses, should be religiously followed. Soil solarization is an excellent tool for eradicating soil-borne pathogens from the potting mixture and can be coupled with biofortification with beneficial microbes. Several new methods of raising planting materials have been developed that ensure healthy and disease-free saplings. Several resistant/tolerant lines are now at our disposal and need to be deployed judiciously wherever such pathogens are rampant.

Phytosanitation not to be ignored: Strict phytosanitation and adequate drainage are very vital for plant health in places with high rainfall and steep terrains. Infected plants should be uprooted along with their root system and destroyed to prevent the lateral spread of pathogens. For this regular scouting and rouging should be carried out in fields. Early detection is very vital not only for soil-borne diseases but also for insect pests like root mealy bugs of pepper and shoot borer of ginger and turmeric.

Plant health means root health: A healthy root system ensures a healthy crop, especially in perennial spices like black pepper. Plants devoid of a sound root system manifest external symptoms like yellowing, wilting and defoliation. Right from early stages necessary protection measures should be adopted to ward off root pathogens and herbivores. Use of biological inoculants having biocontrol, growth promoting and root colonizing traits is an excellent option for root-enhancing biological relationships.

Soil health vital for a root-centric approach: The NER faces vagaries of high rainfall and consequently the nutrient depletion and the erosion. The soils of the region, though rich in organic matter, are acidic to strongly acidic (pH 4.5-5.0). So good soil management that enhances soil function is need of the hour in NER. Cover crops can play a crucial role in soil health management. The soil properties influence the soil water availability too. So we need to rethink our efforts to conserve carbon, water and soil. Our management strategies should help for optimum root growth and function. The subsoil acidity prevalent in NER needs to be addressed for increasing crop rooting depth and water and nutrient uptake. Site-specific supplementary foliar sprays with micronutrients are doing wonders in several crops.

Pesticides only as a last resort: In management of diseases and pests of spices, chemical intervention is practiced as a stopgap arrangement to check secondary spread of diseases. Though most of the pesticides are sprayed as a prophylactic measure, their untimely and unscientific application has precipitated several environmental and economical fallouts across the country. Therefore, dumping of pesticides as prophylactic measures needs to be discouraged in NER. Apply pesticides only as a last resort when pest/disease incidence is above the economic threshold level (ETL). Even on such occasions, only recommended green-labeled pesticides alone may be used.

Future perspectives

Application of insecticides and adoption of pest management measures are to be followed after assessing pest history and threshold levels of infestation. For this, proper awareness on pest &diseases and disease cycles should be made among the farming community. Plant clinics may be set up across NER with proper information dissemination using digital tools. Integrating cultural, prophylactic and bio-intensive methods may reduce the crop losses. These practices will help to reduce pesticide burden on the environment. Our microbial shelves are full nowadays and field deployment of bioagents is a better option for NER. Validation of good agricultural practices (GAP) including methods for eco-friendly management of diseases and pests of the above crops are to be demonstrated through group farming approaches.

We would also like to suggest some policy prescriptions to make the agriculture and allied sectors more viable and prosperous in the NER. As the country is looking towards east for the second green revolution, there will be a huge inflow of seed materials in the next one-decade or so. Strict quarantine measures should be implemented to protect NER from exotic pests and pathogens and a biosecurity policy needs to be drafted exclusively for this region. We need to draft a plant health management guided package of practices for spices cultivation in NER as we are targeting mostly small scale/family farmers (women).

Prospects and potential of spice cultivation in Sikkim

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Introduction

Sikkim which is located at the western extremities of the eastern Himalayas is endowed with a rich diversity of flora and fauna harbouring about 40% of the components that occur in the Indian Subcontinent. This breathtaking diversity results from the geographical location of the state, its unique tectonic and paleoclimatic history with high variation in altitude and climatic conditions. It is spread below the world's third highest mountain range, Kangchenjunga, between 27°4′45′′ to 28°7′45′′ N latitudes and 88°45′′ to 88°35′15′′ longitudes (Anonymous 2013a).

The climate is chiefly determined by its geographical location and elevation which varies from hot tropical in the lower elevations to temperate cool at the middle and arctic cold in higher elevations. It is predominantly moist and wet throughout the year with an average rainfall of about 2000 mm to 5000 mm. The soils of this state are mostly acidic in nature ranging from pH 4.3 to 6.4. Because of the wide diversity in the topography and climatic conditions, agro-climatic zones in Sikkim extend from sub-tropical to warm temperature and cool temperate to alpine zones giving rise to diverse agro ecosystems supporting the rich biodiversity of this area.

The geographical area of the state is 7096 sq. km measuring about 113 km from North to South and 64 km from East to West where almost 82.31 % is under the administrative control of the Forest, Environment and Wildlife Management Department. Therefore, the net cultivable land in Sikkim as recorded in 2010 was 11.1% which includes the large cardamom plantations (Anonymous 2013b). The diversified agro-climatic conditions in Sikkim led to the diversification in the cultivation of horticultural crops comprising of fruits, vegetables, spice crops and flowers which adds considerable amount of income to the marginal farmers.

Scenario of spices in Sikkim

Among the spice crops, cardamom, ginger, turmeric are worth mentioning which enhance the economy per unit area. Large cardamom (*Amomum subulatum*) is the main cash crop supporting the livelihood and improving the economic level of many cardamom growers in Sikkim. It is mainly used as a spice crop, as a flavouring agent and as a medicinal purpose for digestive disorders and pulmonary tuberculosis. India is the largest producer of large cardamom with 54% share in the world market where the state contributes 88% of the country's large cardamom production. The area (23.08 thousand ha) and production (4.08 thousand tonnes) of Sikkim are higher than the area (3.31 thousand ha) and production (0.78 thousand tonnes) of West Bengal (table 1) but the productivity of the latter (0.18 tonnes ha^{-1}) is higher than the former state (0.23 tonnes ha^{-1}) (Agristat 2018).

Table 1. Comparison of area, production and productivity of large cardamom in Sikkim, West Bengal and India

State	Area (000' ha)		Production (000' tonnes)		Productivity (tonnes ha^{-1})	
Year	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Sikkim	22.76	23.08	3.74	4.08	0.16	0.18
West Bengal	3.31	3.31	0.72	0.78	0.22	0.23
India	26.06	26.39	4.47	4.85	0.17	0.18

(Source: Agrisnet 2018)

As Sikkim is an organic state, the produce comes from organic farming has huge potential in the international market (FSADD and HCDD 2012). The cultivated area of large cardamom had increased by 2.3 times in the past 20 years until 2000. In India, the area under large cardamom has decreased from 30.01 thousand ha in 2001-02 to 26.39 thousand ha in 2014-15 (fig. 1). India whilst simultaneously decline in the area was also observed in the same period in Sikkim from 26.73 thousand ha to 23.08 thousand ha (Agristat 2018). The production of this crop during 2014-15 was 4.85 thousand tonnes in India where the bulk share is contributed by Sikkim (4.08 thousand tonnes).

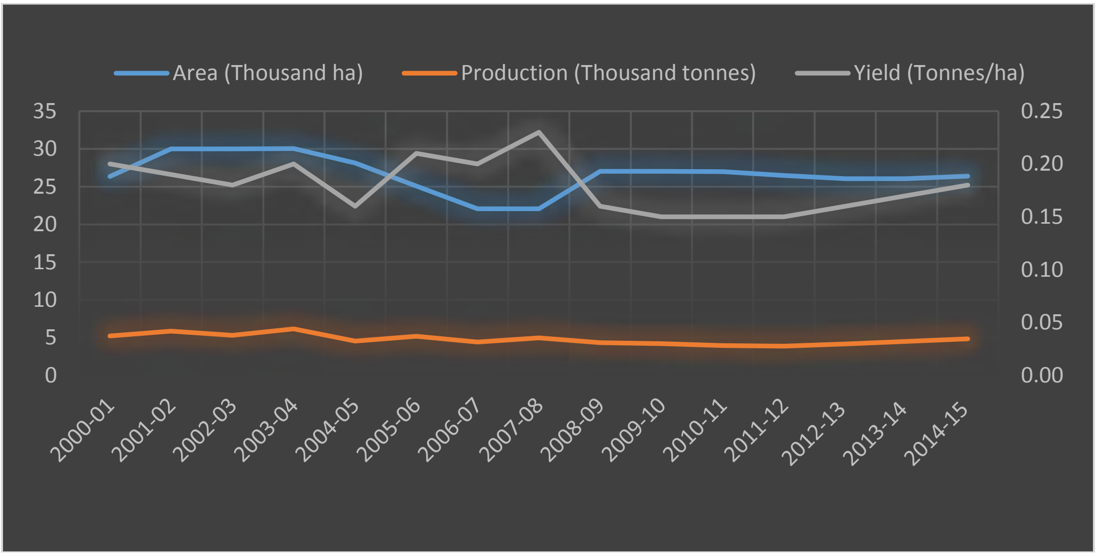

Fig. 1. Area, production and yield of iarge cardamom in India

Large cardamom is grown where the mean annual rainfall is in the range of 1500-3500 mm and the maximum and minimum temperatures at 33^{0}C and 6^{0}C respectively. It is cultivated between altitudes of 600 to 2000 metres which responds to higher altitudes leads to greater intensity of cultivation. It is a shade loving plant where in Sikkim under the traditional agroforestry practices, 70% are under N_2 fixing Himalayan alder (*Aluns nepalensis*) while 30% under the mixed tree agroforestry species (Sharma & Dhakal 2011). It utilised the forest cover on marginal lands giving the right example of how a local mountain niche can be exploited sustainably (Sharma *et al.* 2000). It is grown as a storey crop in hill slopes representing a unique traditional production system irreplaceable by any other commercial farming systems. The slope on these sites varies from 35 to 81%. Planting is directly done into pits on gentle slopes but on medium and steep slopes terraced beds are used giving the highest yield from the gentle slopes. North and north east aspects are preferred to reduce exposure to direct sunlight (Singh *et al.* 1989).

The glory of its cultivation was in peak period during the mid and late eighties (Subbha & Ghosh 2017). But there was a tremendous decline almost by 50% in the plantation area of large cardamom which has a huge impact to India's production thereby dropping the place to second position after Nepal in 2008. Decline set in may be attributed to some disease complex, nutritional factors and inadequate management. This decline has had wide ranging ramifications, disorienting agrarian economy and upsetting cropping patterns. In the normal practice, farmers planted cardamom in the new fields leaving the old ones fallow. Revival strategies were then followed by proper cultivation practices and management of the farm through timely application of manures before flowering and after harvesting, irrigation during dry spell, management of pest and diseases with proper application of bio pesticides along with proper incentives from Horticulture and Cash Crops Development Departments, Sikkim Government and Spices Board (Sharma *et al.* 2016). Increased awareness, extension services, farmer's innovations and the reviving strategies led to gain of momentum in terms of production area and yield from 2008 to 2013.

Ginger is another cash crop grown in Sikkim after large cardamom which is locally called as "Adhua". It is generally marketed as fresh (green) in this state which is mostly used in tea, curries, salad and in pickles. It has many medicinal values and used as carminative, rubefacient, stimulant, gastritis, dyspepsia and flatulent. In Sikkim it is particularly grown by small and marginal farmers' upto an elevation of 300-1500 m above msl. It is partially shade loving crop and can be grown in semi-shaded condition.

Ginger is a high value crop grown organically in Sikkim without the use of any synthetic fertilizers or pesticides results in premium sales. The traditional way of ginger cultivation is terrace cultivation where weeds and bush regrowth are slashed manually or left in the soil as mulch or burnt *in situ*. The area under cultivation of ginger in Sikkim in 2014-15 was 9.3 thousand ha which is very minimal as compared to the area of ginger in India (141.7 thousand ha). The same situation holds for the production where it is only 52.1 tonnes in the state and 760.3 tonnes in the country. But the productivity is at par with India where the former produced 5.6 tonnes ha^{-1} and the latter 5.4 tonnes ha^{-1} in 2014-15. There is an increase in the area under ginger cultivation from 6.47 thousand ha in 2003-04 to 9.3 thousand ha in 2014-15 which shows an improvement in the production from 33.53 thousand tonnes to 52.1 thousand tonnes (Agristat 2018). This improvement may be attributed to the increase in the area and proper cultivation practices by following the organic protocols (FSADD and HCCDD 2012). The increase in area shows that farmers are interested in the cultivation of ginger where as there is a tremendous scope to the increase production thereby the yield per unit area.

Turmeric as a spice in Sikkim is on a steady progress as the cultivation is much easier, the crop being far tolerant to diseases and pest as compared to ginger. It is used as a condiment and a useful dye, with varied uses in drug and cosmetic industries. It is also used as medicine as antiseptic externally on skin and as a stimulant internally. It is mostly grown upto 3500 ft altitude. The area under cultivation for turmeric was 0.85 thousand ha in 2011-12 which was increased to 2.00 thousand ha in 2016-17. The contribution by Sikkim towards the area and production of North Eastern region is very meagre which is about 6% (table 2). This necessitates more awareness about the cultivation of turmeric and standardization to adapt the crop in local conditions.

Table 2. State wise area, production and productivity of turmeric (2016-17)

State	**Area (thousand ha)**	**Production (thousand tonnes)**	**Productivity (tonnes ha^{-1})**
Assam	17.10	17.00	0.99
Manipur	1.40	16.40	11.71
Meghalaya	2.60	16.60	6.38
Mizoram	7.20	27.80	3.86
Nagaland	0.70	9.10	13.00
Sikkim	2.00	5.70	2.85
Tripura	1.30	6.60	5.08
Arunachal Pradesh	0.80	3.80	4.75
Total	33.10	103.00	3.11

(Source: Agristat 2018)

Distribution of major spices in the state

Large cardamom in Sikkim is believed to be first domesticated by the first inhabitants, the Lepchas, by collecting the capsules from the natural forest. As these forests passed into village ownerships the density of tree species declined. Then it passed down to other communities such as the Bhutias and Nepalis of Sikkim, and to the neighboring district of Darjeeling and to southern Bhutan and eastern Nepal (Sharma *et al.* 2000; Sharma *et al.* 2007). It is cultivated in all the four districts of Sikkim *viz*., East, West, North and South but predominantly cultivated in the southern half of the state. Table 3 shows the distribution of large cardamom cultivation in Sikkim.

Table 3. District wise distribution of large cardamom cultivation regions in Sikkim

District	Large cardamom growing region
East	Dalapchen, Deoling, Dhanbari, Upper Samdong, Ari-Takul, Lingdok, Kya-Gumpa
West	Gyangyap, Thingling, Nasa, Buriokhop
North	Chwaang, Lingdong, Salim-Phakel.
South	Tingrithang, Sanganath, Sangmoo, Bakhim.

(Source: Gazetteer of Sikkim 2013)

The *Rai* community of Sikkim was the major grower of ginger, although the *Lepchas* also cultivated ginger for use in religious ceremonies (Gurung & Gurung 2006). The crop became more important where other communities also took up the cultivation in non traditional areas. Ginger is distributed in all the constituents of East district (table 4). Turmeric is grown in few pockets in all the four districts of Sikkim (table 5).

Table 4. District wise distribution of ginger cultivation regions in Sikkim

District	Ginger growing region
East	All constituencies of East district
West	Tikjyek, Melli, Lungik, Rathang, Tikpur, Ambotey, Lower Buriokhop
North	Lower Rongong, Lingdok, Nampatam, Nadey, Passingdong, Lum, Gor, Sangtok
South	Poklok, Kamrang, Namchi, Singithang, Namthang, Rateypani, Melli, Barfung, Rangyang, Ynagyang, Temi, Namphing

(Source: Gazetteer of Sikkim 2013)

Table 5. District wise distribution of turmeric cultivation regions in Sikkim

District	Turmeric growing region
East	Tumin, Dalapchan, Kamarey, Lingdum.
West	Som,Takuthang, Tashiding.
North	Rangrang, Chadey, Sajong, Lum, Manul.
South	Palung, Sorok, Belbotey,Ben.

(Source: Gazetteer of Sikkim, 2013)

Diversity of major spices in the state

The state of Sikkim is a treasure house of germplasm of large cardamom. Local cultivars grown here vary according to their altitude adaptability, environmental stress like water deficit and frost. The farmers grow more than 6 local cultivars developed, tested and cultivated under the prevalent agroclimatic conditions and under different farm management practices. Local cultivars such as Ramsay, Sawney, Bharlang are cultivated above 1500 m whereas Chibey, Ramla and Ramnang are grown within 1000-1500 m and Golsai and Seremna below 1000 m elevations. Seremna, a variety developed by the Limboo tribes of Hee- Bermiok, West Sikkim, is a location-specific cultivar that is tolerant to diseases and pests and is also a high yielder (300–450 $kgha^{-1}$) (Sharma 2016). Dzongu-golsai is a disease tolerant cultivar developed by the Lepchas of Dzongu, North Sikkim. The other landraces in cultivation are Ramla and Churumpho.

The common cultivated local landraces of ginger in Sikkim are 'Bhainse' and 'Gorubathane' that are grown commercially due to their high yield potential and big sized rhizomes (Yadav *et al.* 2004). The 'Bhainse' cultivar can give 1.8 kg rhizome from 50 g seed rhizome hence not only popular in Sikkim but the entire north eastern region. 'Jorethangey' is another local cultivar named after the locality Jorthang in Sikkim (Rahman *et al.* 2009). Other landraces in practice are Majhauley, Nangrey *etc*.

The cultivar Sikkim Local of turmeric is a local landrace grown for its good rhizome yield whereby it was found to be even equal or better than certain improved types. In addition to local landraces commercial cultivars like Suroma, Roma and Lakadong are also culitivated (Anonymous 2013a).

Opportunities bestowed by spice cultivation in Sikkim

Large cardamom has played a vital role in enhancing the income of Sikkim people as it is having export potential and contributes significantly in the state's economy in terms of direct or indirect employment and income generation. It has been fulfilling their basic needs with a provision of easy loans, better houses and better education. This spice is second largest contributor to the income of the people after services and remittance (Sharma *et al.* 2016). The remaining sources of income are other cash crops, beekeeping, and employment under the Mahatma Gandhi National Rural Employment Guarantee Scheme, which together contributed only 4% of household income (Sharma *et al.* 2016). The major markets for this crop are Amritsar, Kolkata, Delhi, Guwahati and Kanpur. Although, in recent years, both production and exports of large cardamom has seen a declining trend, the product holds good potential for export from Sikkim. Exports from the states occur indirectly wherein cardamoms are sold to outside traders in dried form and exported to the Middle East and Pakistan through Amritsar (Anonymous 2009c). The ginger of Sikkim is normally sold as fresh green has huge export prospects because of its good quality. Ginger oil produced from fresh ginger of the state has a huge market because of less aroma chemicals. The promising markets for exports of ginger include those in the vicinity of Sikkim *viz.,* the Asia Pacific region; the potential for exports from Sikkim is thus significantly boosted. Sikkim farmers prefer export to the Middle East and selling in the major domestic metropolitan markets. The quantity of ginger exported out of the state is estimated at roughly 25,000 tonnes. Within India, Delhi (70%) is the major consumer of Sikkim ginger followed by Punjab (10%) thereby the exports are done indirectly through the Delhi markets (Anonymous 2009c). The organic produce has a huge international market which led to opening up a window of opportunity by exporting the organic produce of Sikkim.

Production constraints

Climate change in the Himalayas is causing unpredictable and erratic rainfall, warmer weather, early flowering, less snow in the mountains and melting of snow rapidly, early onset of monsoon, drying of water resources at the end of crop period (Chaudhary *et al.* 2011; Sharma & Rai 2012). This has a huge impact on the cardamom growers which led to decline in production due to rapid drying of springs, spread of diseases, decreased number of pollinators (due to climate change impacts), long dry spells lasting until the flowering season, and lack of training in selection of disease-free planting material, lack of growth management of cardamom for increased productivity, lack of technical knowhow for disease management, and lack of irrigation facilities (Sharma *et al.* 2016).

Most of the spice growers in the state have small land holdings grown on terrace and slopes where the farmers are taking many crops as per requirement on the small piece of land. The erratic weather not only restricts the growth of large cardamom, but constricts the production of other spice crops due to increase incidence of biotic and abiotic stress thereby hampering the adoption of the crop. Non-availability of good quality, high yielding and disease-pest free planting material is another important factor restricting the large scale production of spice crops in Sikkim. Lack of proper dissemination of the funds to the farmers for purchasing of quality planting material and other inputs.

Lack of proper post-harvest technology like cold storage facilities, availability of few processing units in the state is another major constraint in the success of spice cultivation. Curing of large cardamom is mainly done using the traditional curing chambers called *bhattis* involving lots of firewood at household level or farm level which reduce the efficiency of processing the crop. The marketing of spice in the state is mainly by indirect method through middlemen. Lack of proper marketing and transport facilities hinders towards the advancement of the spices in the state.

The future of spice cultivation in Sikkim

Sikkim offers immense potential for large scale cultivation of spices due to its diverse agro-climatic conditions. Now a days due to change in the lifestyle of the people, there is huge demand for organic crops. Sikkim being an organic state has a huge potential for producing as according to the needs of the people. The market can be widen not only in the national but in the international front also. Proper certification of the organic produce will enhance the value of the crops. Most of the areas in Sikkim are under forest cover providing vast resources for green manure, biomass and mulching material which can be judiciously applied in organic farming.

Sikkim is a hot spot of biodiversity having variants of flora and fauna thereby opening the opportunity of exploring, evaluating, domesticating new species of spice and condiments adapted to this region leading to upliftment in the economy of the people. This also provides diversification of other spice crops in this area.

Supply of good quality materials and germplasm sources resistant to biotic and abiotic stress having good yielding ability will enhance the productivity of the crops. Use of tissue culture techniques like micropropagation will lead to vast production of planting material within short span of time. Modern technologies such as DNA fingerprinting and molecular techniques could fasten the detection of resistant cultivars thereby its improvement, thus leading to production of disease free high yielding genotypes.

There is a need to develop proper quality control measures, proper packaging and processing units, transport and storage techniques. Low cost storage structure could improve the storage facilities of the state. Value addition can be done if proper processing units are being set up in this area. Facilitating more efficient services for transfer of technology and proper training to the farmers through extension services would enhance the income of the farmers thereby reducing the migration and shifting to other livelihood by the spice cultivars. Introduction of cardamom, ginger and turmeric to other non-traditional areas will lead to enhanced production of these crops.

Conclusion

The current phase of sustainable agriculture goes parallel with the farming systems of Sikkim. The state harbours a huge potential for diversification of spice crop plantation. Due to decline in the production of large cardamom there is a migration or shifting the cultivation to other livelihoods. Nevertheless it still holds the second highest income generation source. Ginger and turmeric are gaining steady progress which could be well improved through proper awareness of its cultivation from the Government and Universities front. Other spice crops like cherry pepper which holds a huge potential should be cultivated scientifically. Cultivation of this crop could become a highly lucrative venture for small and marginal farmers in the state, which is mainly grown for its green products.

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ORAL PRESENTATIONS

OP6

Effect of different planting time and size of seed rhizome on growth, yield and quality of ginger (*Zingiber officinale* Rosc.) cv. Nadia

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A study was conducted to analyze the effect of different planting time and size of seed rhizome on growth, yield and quality of ginger. The experiment comprised of four different dates of planting *viz.,* D_1: 15th February, D_2: 15th March, D_3: 15th April, D_4: 15th May with three different size of seed rhizome *viz.*T_1: Single bud, T_2: Double bud and T_3: Multiple buds. The results indicated that different dates of planting had significant influence on the growth and yield attributing parameters. Planting on 15th April recorded higher yield parameters like number of primary fingers (22.33), secondary fingers (62.48), yield/clump (1.20 kg), yield/ha (31.78 t) followed by February 15th planting with 22.37 primary fingers, 56.83 secondary fingers, 0.92 kg rhizome/clump and 25.42 t/ha rhizome yield, respectively. Seed rhizome with multiple buds recorded highest yield *i.e.,* number of primary fingers, secondary fingers, yield/clump, projected yield (20.73, 55.22, 1.13 kg/clump, 27.05 t/ha), followed by double bud (18.99, 47.97, 0.78 kg/clump, 23.68 t/ha). However, planting date or size of seed rhizome had no significant influence on quality parameters. The economics of different treatment combinations indicated that, highest net return of Rs. 4,98,450/- was obtained from the treatment, multiple buds planted in the month of April with the highest BCR of 2.80.

OP7

Integrated management of bacterial wilt of ginger using calcium chloride and *Bacillus licheniformis*

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Ginger bacterial wilt caused by *Ralstonia pseudosolanacearum*, is the most devastating disease and has been reported from all most all the ginger growing countries. Many strategies have been adopted for the control of bacterial wilt which have been met with limited success under field conditions. The present study was undertaken with calcium chloride to investigate its effect on the survival of *R. pseudosolanacearum in vitro* and on the control of bacterial wilt *in planta* along with *Bacillus licheniformis* GAP107- MTCC 12725, a ginger apoplastic bacterium. Results revealed that calcium chloride @ 2-4% inhibited the growth of *R. pseudosolanacearum in vitro*. *In planta* evaluation of $CaCl_2$ as well as *B. licheniformis* GAP107 after challenge inoculation showed 71%, 98% and 100% reduction in bacterial wilt, respectively with GAP107, 3% and 4% concentration of $CaCl_2$. Results of field evaluation showed 100% disease suppression in a severely bacterial wilt affected plot after solarization and amending with $CaCl_2$ (3%) as well as with *B. licheniformis*. Both the treatments reduced *R. pseudosolanacearum* population from 10^8 to 10^3. Hence, it is suggested that either $CaCl_2$ (3%) or *B. licheniformis* GAP 107 along with soil solarization would serve as an

integrated strategy for the control of bacterial wilt under organic/inorganic system of ginger cultivation.

OP8

Leaf blight of ginger caused by *Bipolaris rostrata*, an emerging disease in Kerala and Karnataka

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Foliar diseases in ginger are considered as a major production constraint due to the drastic reduction in rhizome yield through the damage of chlorophyllous tissues resulting in 13 to 66 per cent yield loss and their incidence is increasing due to climate change. Hence, extensive surveys were conducted in the ginger growing tracts of Mysuru, Chamarajanagar and Uttara Kannada districts of Karnataka and Wayanad and Kozhikode districts of Kerala during 2016 and 2017 to record the incidence of leaf diseases. Leaf blight of ginger was characterized by reddish brown lesions in the surveyed locations and the incidence ranged from 0–40%. Symptoms manifested with the formation of reddish brown oval shaped water soaked discrete spots with yellow halo on the margin and distal end of the leaf lamina. Later these spots gradually increased in size and often coalesced to form large discoloured areas which finally lead to the blighting of entire leaf. Pathogenicity was confirmed by isolating the fungus from diseased leaves and inoculating on healthy ginger plants. Leaf blight causing fungal isolate was identified as *Bipolaris rostrata* (Drechs.,) Shoemaker [synonym- *Exerohilum rostratum*] based on conidial morphology and molecular characterization. This is a new report of *B. rostrata* causing leaf blight on ginger.

OP9

Morphological and molecular characterization of *Fusarium oxysporum* f.sp. *vanillae* inciting root and stem rot disease in vanilla and its management

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Vanilla planifolia popularly known as Prince of Spices is a fleshy perennial liana cultivated in and around Western Ghats for its natural compounds used in several ice creams, chocolates and beverages. *Fusarium oxysporum* f.sp. *vanillae* (FOV) is one of the most destructive pathogens causing severe yield loss and during the surveys conducted in 2016, maximum incidence of 25% was noticed in Kodagu district, Karnataka. The pathogen was isolated and morphologically identified as *F. oxysporum* based on the conidial, chlamydosporial and cultural characters. Further to confirm the identity of pathogen, 18S rDNA or ITS region DNA was amplified and sequenced. A phylogenetic tree was constructed using Maximum likelihood showed clearly two distinct clusters which clearly out grouped *Colletotrichum gloeosporioides* and all other *Fusarium* sp. in one clade. The seven isolates used in the study grouped under *F. oxysporum* clearly separating from other

species of *Fusarium.* In order to control the pathogen, isolation of microbiota from healthy plants yielded 10 fungal and 30 bacterial microbes, these were tested for its efficacy against FOV, among them isolate VREN1 tentatively identified as *Bacillus amyloliquefaciens* showed maximum reduction of pathogen under *in vitro*. Growth promotion activity like siderophore production, IAA production, GA production was recorded maximum in *Bacillus amyloliquefaciens* VREN1.

OP10

Growing coriander (*Coriandrum sativum*) in acidic soil (Typic Haplustalf): An option for doubling farmer's income

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Field experiments were carried out consecutively for three years in acidic soils of Ranchi using Jharkhand coriander (*Coriandrum sativum*) with various fractions of recommended dose of lime (RDL) *i.e*, 25%, 50%, 75% and 100%. The results revealed that, seed yield of coriander was not significantly influenced by lime. However, it was 8-9% more at higher levels of lime than control. The stover yield and nitrogen uptake was significantly higher where 100% recommended dose of lime was applied. However, P uptake did not show any statistical variation with lime application. Potassium uptake was more at 75% and 100% application of lime. Uptake of sodium was higher over control, however it was marginally higher with higher doses of lime. Iron, zinc, manganese and copper uptake was increased with lime and declined beyond 75% RDL. Soil available nitrogen and potassium increased with lime and copper, iron and manganese decreased marginally, whereas availability of phosphorus and zinc remained unchanged. Moreover, soil EC and pH increased and soil organic carbon decreased. Most of the growth and yield data were at par with lime, indicating that coriander can be adapted well in acidic soils (pH 5.5). Most importantly, the yield nearly doubled (28.9 q ha^{-1}) in these medium to higher fertile acidic soils as compared to traditional growing areas which broke the yield barrier of the variety 'Ajmer Coriander-1'.

OP11

Growth and seed yield of coriander (*Coriandrum sativum* L.) *cv*. Ajmer Coriander-1 as influenced by different levels of nitrogen and phosphorus in gangetic alluvial plains

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Coriander (*Coriandrum sativum* L.) is an annual herb and it is one of the first seed spice to be used by mankind. Nitrogen and phosphorus are the two major nutrients required for the good production or yield of coriander. To determine the best combination of nitrogen and phosphorus for maximum vegetative growth, seed yield and quality parameters of coriander (var. Ajmer Coriander-1), the present investigation was carried out during two consecutive *rabi* seasons at

Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. Two different levels of nitrogen (@ 40, and 60 kg/ha) and four different levels of phosphorus (@ 30, 40, 50 and 60 kg P_2O_5/ha) in different combinations were applied to the plants. The result showed that, the highest number of umbels per plant, umbellate per umbel, seeds per umbel, seed yield and essential oil content in seed was recorded with treatment N_2P_2 (60 kg nitrogen/ha + 40 kg P_2O_5/ha), whereas combination with higher or lower dose showed lower values. Hence, the application of N @ 60 + P @ 40 kg per ha was found to be the best for coriander cultivation in the gangetic alluvial zone of West Bengal.

OP12

Knowledge and adoption level of improved King Chilli (*Capsicum chinense*) cultivation practices among farmers in Peren District, Nagaland

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King chilli (*Capsicum chinense*) belongs to the family *Solanaceae* and is one of the hottest chillies in the world. Considering its high potential and commercial value, a study was conducted to examine the knowledge and extent of adoption of improved King chilli cultivation practices among the farmers in Peren district of Nagaland using ex-post facto research design. The study revealed that, King chilli farmers had mean age of 40.08 years, majority of them were illiterate, had marginal size of land holding, having income in the range of Rs. 23844 to Rs. 169230 without proper training exposure but had very high level of marketing orientation. Majority of the respondents had adequate knowledge on nursery bed preparation, intercultural operations, harvesting (time, interval, stage), cleaning, grading and packaging, storage and transportation. Further only few of them had knowledge on insect pest and disease management while none of the respondents had knowledge on seed treatment, soil treatment, field preparation, transplanting, and requirement of plant population per hectare. It was found that all the respondents had fully adopted the improved practices of sowing and mulching, intercultural operations, storage and transportation. The study concluded that there exist a great potential for King chilli cultivation but state department needs to impart need based training to farmers in the areas specified so that farmers become agri-preneurs thereby enhancing their level of income and prosperity.

SESSION III b:
CLIMATE RESILIENCE IN SPICE CROPS PRODUCTION AND MITIGATING CLIMATE CHANGE

LEAD LECTURES

Climate resilience in spice crops production

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Introduction

Honourable Prime Minister of India Shri Narendra Modiji, at World Economic Forum's Annual Meeting 2018 in Davos, Switzerland listed 'climate change' as the first major challenge which is posing great dangers to humanity. Glaciers are melting, many islands are sinking or have sunk and it was emphasized to mitigate climate change (WEF 2018). Ever-mounting evidences show that human activities are altering the climate around the world. A growing number of international leaders now warn that climate change is, in the words of U.K. Chief Scientific Advisor David King, "the most severe problem (climate change) that we are facing today—more serious even than the threat of terrorism." Climate change will likely trigger severe disruptions with ever-widening consequences for local, regional and global security. Droughts, famines and weather-related disasters could claim thousands or even millions of lives and exacerbate existing tensions within and among nations, fomenting diplomatic and trade disputes. In the worst case, further warming will reduce the capacities of earth's natural systems and elevate already-rising sea levels, which could threaten the very survival of low-lying island nations, destabilize the global economy and geopolitical balance and incite violent conflict (Janet Sawin 2018).

Climate change VS Climate variability

Weather describes current atmospheric conditions, such as rainfall, temperature and wind speed, at a particular place and time. It changes from day to day. Climate is the average [or 'normal' (30 years)] pattern of weather for a particular place over several decades. Changes in climate are hard to detect without very long-term records. Climate variability refers to shorter term (daily, seasonal, annual, inter-annual, several years) variations in climate, including the fluctuations associated with El Niño (dry) or La Niña (wet) events. Climate change refers to long-term (decades or longer) trends in climate averages such as the global warming that has been observed over the past century and long-term changes in variability (*e.g.* in the frequency, severity and duration of extreme events). Climate change is real and its implications are going to be borne by all, most especially the poorest of the poor. The impact of climate change on rainfall pattern is not going to be a temporary phenomenon. This is only the beginning and delayed monsoons, unexpected rains and heavy downpours are likely to be the rule rather than the exception (William Dar 2009).

Monsoon, floods and drought

India's agriculture is a gamble with the monsoons. About 60% of India's farms depend on rains, so the monsoons are indeed critical to India's agriculture, which accounts for a sixth of the country's economic output. The Indian monsoon is remarkably stable as a whole, with a mean total of around 850 mm in the months of June to September and an inter-annual (year-to-year) variation of only around 10% in most cases. Even these relatively small variations in the Indian monsoon can influence agricultural production and the stocks and commodities market, so a 5-10% change on top could have significant impacts (Andy Turner 2018).

For many people in India, it is the variability of rainfall on shorter time scales that has the biggest impacts – intense heavy rainfall leads to flooding; breaks in the monsoon for a week or more lead to water shortage and agricultural drought. Floods and droughts are a normal occurrence in India. In 2002 for example, a break in the monsoon rains saw July receiving only about 50% of its normal rainfall, leading to cuts in agricultural output and declining GDP. Thinking about climate change in the context of how these extreme events will change can help farmers and other end users to understand its implications. It's difficult to say for certain that a particular extreme event for the monsoon is attributable to anthropogenic climate change, but we do know that with a warming climate more moisture can be held in the atmosphere, leading to heavier rainfall when it does occur. It is also thought that, inter-annual variability of the monsoon will increase in future, whatever happens to its main driver, El Niño. However, it will not be until we have a better capability at simulating the day-to-day and intra-seasonal variability of the monsoon in our climate models that we will have more confidence in our projections of this important variability. Given the increasing population of the region and need for food security, improving the scientific understanding in these areas is of utmost importance (Turner & Annamalai 2012). Temporal and spatial variation of rainfall during 1871-2016 in India is given in table 1 and rainfall variability (CV%) in NE region is relatively lesser than other zones. Net annual temperatures in India in 2030s, with respect to 1970s, will increase from 1.7-2.2°C. Extreme temperatures are expected to increase by 1-4°C, with maximum increase in coastal regions (IPCC 2014). In some places, diurnal variation is on in the increasing trend, for example, in our ICAR-IISR Regional Station, Appangala, Madikeri, Kodagu District, Karnataka, we have noted an increasing trend in diurnal temperature over the years (1986 to 2017) (fig. 1) and this region is one of the important spices and plantation crops producing district in the country.

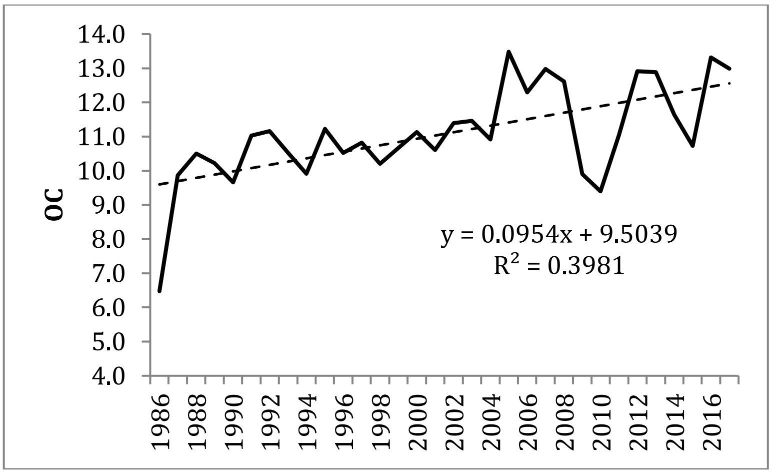

Fig. 1. Diurnal variation in air temperature over the year (1986-2017) at ICAR-IISR Regional Station, Madikeri, Karnataka

Table 1. Monthly seasonal and annual rainfall during 1871-2016 (1871-2014 based on 306 stations and 2015-2016 based on IMD subdivisional rainfall) of All India and macro regional level

Month/ Season/ Annual	North west India (6 Subdivisions Area 634272 sq. km.)		West Central India (9 Subdivisions Area 962694 sq. km.)		North east India (4 Subdivisions Area 267444 sq. km.)		Central North east India (5 Subdivisions Area 573006 sq. km.)		Peninsular India (6 Subdivisions Area 442908 sq. km.)		All-India (30 Subdivisions Area 2880324 sq. km.)	
	Mean	**CV (%)**	**Mean**	**CV (%)**	**Mean**	**CV (%)**	**Mean**	**CV (%)**	**Mean**	**CV (%)**	**Mean**	**CV (%)**
JAN	6.8	942	9.4	1068	14.1	900	15.6	841	10.9	1297	10.7	702
FEB	7.1	1137	9.5	1009	28.0	661	18.4	889	9.0	1390	12.4	708
MAR	5.6	1398	10.0	1173	60.2	562	14.6	997	13.7	1127	15.2	612
APR	3.9	1441	12.4	731	130.8	346	16.3	793	39.1	537	26.4	344
MAY	10.7	1041	21.2	790	234.1	246	41.8	521	85.7	495	52.7	302
JUN	63.9	592	168.9	316	377.7	173	160.9	387	165.3	197	163.0	222
JUL	187.6	356	306.4	204	396.7	165	315.5	189	189.6	228	272.5	137
AUG	157.6	453	267.0	217	352.7	166	307.5	164	158.1	272	242.2	155
SEP	83.1	714	185.2	317	280.0	200	208.0	251	147.8	301	170.3	214
OCT	12.1	1633	59.3	622	140.3	458	71.5	682	180.4	327	77.5	369
NOV	4.4	2173	17.7	1193	27.7	1023	13.7	1145	121.3	540	30.8	590
DEC	4.1	1494	7.3	1648	8.4	1373	6.3	1351	41.4	766	11.7	794
JF	14.0	716	18.9	746	42.2	538	34.0	615	19.9	950	23.2	499
MAM	20.3	773	43.7	508	425.1	192	72.9	421	138.6	328	94.4	216
JJAS	492.4	261	927.6	132	1407.2	90	992.1	115	660.9	148	848.1	98
OND	20.7	1083	84.3	506	176.4	407	91.5	560	343.2	269	120.1	286
ANNUAL	547.6	249	1074.6	130	2051.2	89	1190.7	111	1162.8	117	1085.9	93

Data source: Indian Institute of Tropical Meteorology (IITM), Pune
Note: JF=Jan-Feb; MAM=Mar, Apr, May; JJAS=Jun, Jul, Aug, Sep; OND=Oct, Nov, Dec.

Vulnerability areas due to climate change

National Initiative on Climate Resilient Agriculture (NICRA) has categorized the vulnerability of districts in Indian states for changing climate based on sensitivity index, exposure index, adaptive capacity index and vulnerability index (Rama Rao *et al*. 2013) and reported that, out of 572 districts 115, 115, 114, 114, 114 districts falls in very high, high, medium, low and very low vulnerability category, respectively. The status of North East is listed below (table 2.) Vulnerability is more seen in Rajasthan (25 districts), Gujarat (14), Karnataka (14), Madhya Pradesh (14), Maharashtra (12), Uttar Pradesh (12) and North East is relatively less.

Table 2. Degree of vulnerability in the districts of North Eastern states due to climate change (2021 -50)

State	Very high	High	Medium	Low	Very Low	Total
Arunachal Pradesh	0	0	0	5	9	14
Assam	1	1	1	7	13	23
Manipur	0	0	3	3	3	9
Meghalaya	0	0	1	3	3	7
Mizoram	0	0	1	7	0	8
Nagaland	0	0	0	3	5	8
Sikkim	0	0	0	2	2	4
Tripura	0	0	0	0	4	4
All India	115	115	114	114	114	572

Spices and climate resilience

Climate resilience can be generally defined as the capacity for a socio-ecological system to: (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (2) adapt, reorganize and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

Spices are cultivated in different agro-climatic regions from tropical to temperate. India is blessed with diverse climatic conditions and every state in India cultivates one or the other spices and production capacity of the state vary. Black pepper, small cardamom and tree spices such as clove, nutmeg, cinnamon, allspice, curry leaf and vanilla are cultivated in and around Western Ghat region; seed spices are concentrated in Western India; chilli, ginger, turmeric and coriander are cultivated throughout India, almost in all the states; large cardamom is confined to Eastern Himalayas; whereas, saffron grows in Jammu and Kashmir and parts of Himachal Pradesh. Some spices require specific ecological niche and others have wider adaptability. The percentage share of spices production of states to all India spices production is high in Rajasthan (17.1), Andhra Pradesh (13.5%), Madhya Pradesh (13.3%), Gujarat (10.7%) and Telangana (9.7%). Although more than 50 spices are cultivated in India, we have area and production statistics only for around 20 spices. Spices share 14.8% in area and 2.7% in production of total horticultural crops in India. The global demand for a variety of spices has continued to rise in the past few years owing to the vast rise in the consumption of convenience foods, snacks and confectionary. The widened market for processed and ready-to-eat food products has also had a vast positive impact on the overall global consumption of a variety of spice. Technavio’s analysts forecast the global spices and seasonings market to grow at a CAGR of global spices and seasonings market 5.12% during the period 2017-2021.

Steps in resilient spice production

i. Building resilience in soil and organic farming

Soil health is the key factor that determines resilience of crop production under changing climate. A number of interventions are made to build soil carbon, control soil loss due to erosion and enhance the water holding capacity of soils, all of which build resilience in soil. Mandatory soil testing is to be done in all villages to ensure balanced use of chemical fertilizers. Improved methods of fertilizer application matching with crop requirement is necessary to reduce nitrous oxide emission. Practice of organic farming would enhance resilience in the farming system, ensures better soil health with ecosystem services as a result sustainability in the agriculture production and quality produce particularly spices.

ii. Climate resilient varieties

In India, more than 150 spice varieties have been developed over the years through R & D efforts. The first hybrid variety of black pepper - Panniyur 1, developed is still the dominant cultivar not only in India but also worldwide. Development of high quality varieties paved way for quality upgradation of spices. Climate resilient varieties of turmeric *viz.,* IISR Pragati (short duration, nematode resistant variety overcoming drought also) and NDH 98 (saline tolerant, stable yield across the country), ginger variety-IISR Mahima (nematode tolerant), cumin variety-GC4 (wilt tolerant), dual purpose varieties of coriander and determinate types of fenugreek (suitable for mechanized harvesting) played an important role in increasing the income of farmers. Spices varieties tolerant/resistant to biotic and abiotic stresses are given below (table 3). In many seasonal crops, early duration drought, heat and flood tolerant varieties and varieties for other adverse conditions are available, but in spice it is few and far between. It has to go a long way to breed suitable ideotype in spice to tackle climate change (Divakara Sastry 2017).

Table 3. Some of the **s**pices varieties tolerant/ resistant to biotic and abiotic stress

Crop	Variety	Tolerance/resistance
Black pepper	IISR Thevam & IISR Shakthi	Tolerant to Phytophthora foot rot
	Pournami	Tolerant to root knot nematode
Small cardamom	ICRI 5	Tolerant to drought
	IISR Avinash	Tolerant to rhizome rot
	IISR Vijetha & Appangala 2	Resistant to *Katte/ mosaic* disease
	PV 2	Tolerant to stem borer and thrips
	ICRI 2	Tolerant to *Azhukal*/capsule rot
	ICRI 3	Tolerant to rhizome rot
Turmeric	IISR Pragati	Resistant to nematode
	Suguna & Sudarshana	Resistant to rhizome rot
	NDH 98	Tolerance to salinity
	BSR 2	Resistant to scale insects
	Pant Peetabh	Resistant to rhizome rot
Coriander	ACr 1	Resistant to stem gall
	Co.2	Suitable for saline and alkaline and drought prone areas
	Sindhu	Suitable for rainfed areas, tolerant to wilt, powdery mildew as well as drought condition, medium duration
	RCr 20	Suitable for rainfed crop or limited moisture condition
Cumin	GC 1	Resistant to cumin wilt

iii. Establishment of seed bank / nucleus planting material stock

The extreme weather and weather aberrations are common nowadays leading to the loss of standing crops and as a result farmers may loss the seed stock. Hence, it is essential to have sufficient quantity of seed in reserve to continue the crop production. This may be taken up in community approach with the help of government support. Community nurseries for perennial spice crops are also important to supply continuous requirement of quality planting materials for new planting or gap filling or replacing older varieties.

iv. Capturing the season and timely operations

Timely operations always top the list in decision making and implementation and it is a 'non-monetary input', one should select right time of planting/sowing, irrigation, plant protection, harvest *etc*. There seems to be yield differences in morning sown crop and afternoon sown crop in a location as reported by somebody, such is the importance attached with time of planting to facilitate full utilization of the season as it assumes more importance in the changing climate. Agro-met advisories services (AAS) are available for each district for all the states. The district AAS Bulletin issued by Indian Meteorological Department (IMD) on weekly basis with input from State Agriculture Universities and ICAR Institutes and can be accessed from http://www.imdagrimet.gov.in/. It may be utilized for taking crop management decisions. The Government of India has taken adequate effort for improving the precision of predication of weather system and forewarning. It may be noted that there is an on-line support of district wise contingency planning for all the states available with ICAR-Central Dryland Agriculture Research Institute (CRIDA), Hyderabad (http://www.crida.in:82/contingencyplanning/), for delayed monsoon, early season drought, mid season drought and late season drought.

v. Water harvesting and irrigation techniques

Spices are cultivated both in rainfed and irrigated lands. Time and again it is told that Indian agriculture is rain dependent and human settlement started in around water bodies. The water bodies, temples, sacred groves *etc*., are the symbols of our villages and now in most places surface water tanks have disappeared. Ground water depletion is at an alarming rate and urgent need for community-based groundwater management and an understanding of how to build and maintain the aquifers that hold and supply groundwater. Water harvesting and recycling should be an integral part of spices production particularly in rainfed production system. Practice of mulching conserves the moisture in rainfed system. In irrigated system one should adopt efficient water management practices using drip and sprinkler systems *etc*.

vi. Adoption of novel crop production and protection technologies

New technologies are generated regularly from research institutes and those should be demonstrated on a larger area for adoption by the farmers. The technologies such as seed priming, seed hardening and encapsulation for early germination to express better growth and vigour and drought tolerance; transplanting techniques to reduce the main field duration and save the seed, drip-fertigation to enhance the fertilizer use efficiency and save water, biocontrol application for residue free spices *etc*., have to be used on regular basis for sustaining the production. In rainfed situation, protecting the crop from scorching sun particularly during summer is essential. For example, spraying lime @1.5% or spraying kaolin @2.0% protects the black pepper crop, preventing leaf fall and defoliation due to sun scorching. Providing over sprinklers for evaporative cooling or shade net also reduces the heat load on plant.

vii. Protected cultivation

The green house, net house, poly – tunnels *etc*., offer a great scope for protected cultivation of crops, it is mainly used for vegetables like tomato, capsicum, cucumber and flower plants. In spices, the polyhouse/net house structures are used mainly for raising quality planting materials. However, many farmers have taken up cultivation of ginger, coriander *etc*., in commercial scale using protected cultivation techniques. It is useful for commercially important low volume and high value spices crop cultivation, but it has to go a long way to develop low cost structures at affordable price for small and marginal farmers of our country. Standardization of potting mixtures with available local materials like agricultural wastes is essential and use of appropriate containers is of utmost importance depending upon the nature of crop and for rhizomatous crop bigger bags to allow the growth of rhizome has to be considered while selecting the containers. Irrigation and fertigation schedules are not adequately addressed for growing spices in protected cultivation.

viii. Cropping system

Practice of cropping system is always a better option than monoculture and it is a way to protect farmers from the vagaries of weather/pest and diseases/market fluctuation. When two or more crops are grown along with main crop, under unforeseen situations, even one crop fails, some income or produce could be obtained from other crops in the intercropping system. Under favourable conditions, farmers will get additional income or other economic produces like vegetable, fodder, green manure *etc*. The choice of crops for intercropping mainly depends on farmer's need.

Black pepper is well adapted to grow as a under crop/mixed crop/intercrop with plantation crops. Humid rainforest ecosystem in the tropical and sub-tropical climate provides appropriate environment for raising annual, biennial and perennial crops as inter and mixed crops in high density multi-species cropping systems. Ginger, turmeric, banana, cocoa, yam and cereals like upland paddy, pulses like red gram, vegetables, flowers, fodders and other annuals are intercropped with pepper. Pepper is also intercropped with coffee, tea, arecanut and coconut. Cardamom is a shade loving plant grown under tall forest shade trees and it offers great scope as a mixed crop in coffee plantations in the tropical forests, besides being grown in arecanut and coconut plantations. The tree spices such as clove, nutmeg, cinnamon and allspice can be interplanted with cardamom.

Ginger and turmeric can be grown as sole crops under open or shade, apart from as a component in inter/mixed cropping systems. Ginger and turmeric are intercropped with vegetables, pulses, cereals, oilseeds and other crops. Ginger and turmeric can also be grown as mixed crop with castor, redgram, finger millet and maize. As these spices require partial shade, they can be grown as an undercrop in coconut, arecanut, rubber, orange, stone fruit, litchi, guava, mango, papaya, loquat, peach, coffee and poplar plantations. They are the most favoured crop component under agroforestry. However, crop rotation is essential, as ginger and turmeric deplete more nutrients in the soil coupled with rhizome rot problem under monoculture continuously. The crop is rotated with tapioca, chilli, sesame, little millet and dry paddy in rainfed conditions and finger millet, groundnut, maize and vegetables are rotated with ginger under irrigated condition. Crop rotation using tomato, potato, chilli, eggplant and peanut should be avoided, as these plants are hosts of the wilt causing pathogen. Tree spices are important group of spices suitable for cropping system with plantation crops. Seed spices also are suitable to grow as a intercrop in fruit orchards (Meena *et al.* 2017).

ix. Integrated Farming System (IFS)

The crop-based husbandry alone will not generate adequate employment and income to small and marginal farmers in the context of climate change. It is essential to integrate crops with animal husbandry, bee keeping, mushroom production, sericulture *etc*. There are several improved farming system models for different agro-climatic regions of India that has to be adopted to sustain the production and survival of marginal and poor farmers.

x. Institutional support

Institutional support is very much essential in the form crop insurance, marketing, storage infrastructures, loans, buy back system, crop advisories *etc*. Providing machineries to the farmers on nominal rent facilitates practice of mechanization and reduce the postharvest loss.

Conclusion

Spices are grown in 3.6 million ha with a production of 8.1 million tonnes, that shares 14.8% in area and 2.7% in production of total horticultural crops of India. Among 43 principal agricultural commodities exported from India, spices stands in fourth place and contribute 8.7% of agricultural products export. Spices market is expected to grow at a compound annual growth rate (CAGR) of 5.12% during the period 2017-2021. Climate change is evident in the form of rise in temperature and ill-distribution of rainfall *etc*. Building resilience in soil, practice of organic cultivation, growing climate resilient varieties, adopting water harvesting systems, efficient irrigation and fertilizer use techniques, use of biocontrol agents, growing multiple cropping with integrated farming system, following crop advisories for timely operations, protected cultivation and institutional support would help the spice production to cope up with climate resilience in India.

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Impact of climate change in cardamom cultivation

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Introduction to climate and cardamom in the mountain tropics and forests

In humid tropics, high altitude areas are the lone regions where low temperature predominates and is an important factor in plant, animal and human life. Cardamom is one of the few high value spice crops cultivated only in the mountains and highlands of the tropics. Except Guatemala, the crop is grown under partial shade of tropical forests in India (Southern Western Ghats), Sri Lanka (Knuckles Mountain) and Tanzania (Usambara Hills). Successful cultivation of cardamom can be achieved in Indian Cardamom Hills (ICH) beginning from 700 upto 7000 feet from mean sea level (MSL). Cardamom being rain loving crop prefers rainy and cool environment to hotter dry climates. Most places in ICH enjoy typical monsoon climate except the eastern most slopes where the annual mean maximum and minimum temperatures attain correspondingly 38ºC and 16ºC. The climate in the tropical high uplands are extremely peculiar in their combination of features because of the position of tropical belt on the planet earth and the general circulation of air masses at low latitudes. In tropical systems, the air temperature decreases with increasing altitudes without the confounding effects of its seasonal change. Air temperature changes by a much larger degree in a day than seasonally and the growing period is no different from lowland to forest limit, which is quite different from temperate systems where the growing period usually shortens with increasing altitudes. In tropical mountains with abrupt and irregular relief, the horizontal surfaces are either reduced to small areas or nearly inexistent. Under such circumstances, the concept of regional climate looses most of its value. Therefore, topo and microclimates become ecologically more meaningful for cardamom than the regional climates. Three factors such as slope angle, slope aspect, roughness and relative topographic position determine the microclimatic requirement of cardamom. The first two modify the diurnal temperature and humidity through their action on insolation while, topography influences night climate through its action on downward cool air movement and the daily cycle of valley winds. In many tropical mountains, the daily weather pattern actually determines the insolation on the west facing slopes to be significantly reduced by cloudiness or fog during afternoon, in contrast to east facing slopes receiving early morning sunshine. Sites of easterly aspect receive greater direct insolation and therefore experience drier, higher maxima and lower minima temperatures. Environmental conditions at mountain altitudes have been characterized by low temperature, low air pressure, low humidity and uneven distribution of light and high speed wind. Cyclic changes of climate in the tropics are best illustrated by comparing solar radiation along the latitudinal gradient from the equator (0˚) to middle latitudes (50˚). Therefore, the tropical climates differ sharply from the middle-and-high latitude climates in having reduced month-to-month variation in both the mean temperatures and duration of the day, a fact that surely permits us to consider tropical environments to be remarkably constant.

Climatic factors such as relative humidity show regular variations and are inversely correlated with air temperature. Mean air temperature is therefore relatively constant year round in the tropics. The trade winds and atmospheric circulation associated with them are responsible for the widespread occurrence of highly seasonal rainfall climates within tropical latitudes. Besides their year-round constancy in the mean temperature, some tropical climates show distinctive patterns in the distribution of precipitation and consequently in the relative humidity and soil water availability. Rain, with condensational heat in its formation, is the driving force for the atmospheric circulation in the tropics, while the convergence of moisture-laden air in the lower atmosphere fuels convection. However, the monsoon rain is highly organized in space depending on the distinct connective centers and abnormal changes in these give rise to floods and droughts, causing economic damage to agriculture.

Irrespective of the causes of rainfall seasonality, many tropical areas have either two or four contrasted seasons, including rainless periods that extend from 1 to 6 or 7 months. This annual pulsation may induce significant changes in the temperature regime. Since high cloudiness prevailed during the rainy seasons, the total solar radiation at ground level decreased, whereas high relative humidity at night greatly diminished the coldness due to long wave out going radiation from the ground and forest and crop vegetation. These combined effects decreased the amplitude of daily temperature variation. The opposite conditions prevailed during rainless period, when low cloudiness, clear skies and dry atmosphere lead to higher day and lower night temperatures that increased the amplitude of daily temperature fluctuations. In this way, seasonality in rainfall brought thermoperiodism, an annual cycle with dampened temperature oscillations and higher night minima during the wet seasons and with greater temperature fluctuations and lower night minima during dry seasons. This variability in oscillations of temperature combined with humidity seasons became a conspicuous feature of mountain climates.

Rainfall varies much more than temperature in tropical mountains since rainfall heavily depends on the precise geographic conditions of each mountain system. As a general rule, the amount of precipitation increased from low altitudes to a maximum at a middle altitude, roughly corresponding to the occurrence of montane or the cloud forests and then decreased more or less steadily to the highest elevations. All tropical mountains differed from adjacent lowlands and high rhythmic higher latitudes, principally by the lower temperatures prevailing throughout the annual cycle. Therefore, the climate of the high tropical mountains was responsible for these areas with peculiar environments that are ecologically apart from both extra tropical mountains and from tropical low lands.

The tree cover in the tropical mountains has been used to modify the heat budget of a land surface by its influence on incoming and outgoing radiation, as well as by its direct modification of humidity and temperature below the dense forest canopy. Mean and maximum temperatures were lower under the forest canopy than under the sparse cover, but the minimum temperatures were higher in the forest 10 cm above the forest vegetation. The forest canopy functioned effectively as a screen for short and long wave radiation. Temperature fluctuations were thus dampened and the daily climatic cycle was less contrasted in forested tropical mountains. Microclimatic conditions in a forested system have been playing a crucial role in the development and severity of plant diseases and crop diversifications either encouraged or inhibited depending on the particular requirements of the organisms. Macro and micro-climate plays a very important role in the population dynamics of sucking pests.

Observed climatic variability and change in Cardamom Hill Reserves (CHR) and their impact in cardamom cultivation

Crop agriculture including agroforestry is vulnerable to climate change and variability through direct (*i.e.*, abiotic) effects on crop development and yield (e.g., changes in temperature or precipitation) as well as through indirect effects arising from changes in the severity of pest, insect and disease pressures, availability of pollination services and performance of other ecosystem services that affect agricultural productivity.

The cultivation of cardamom across regions is impacted directly and indirectly by the on-going perceived climatic change. The negative effects of climatic change have been observed very frequently in cardamom hills. Of the seven years in the second decade of the century, three years (2013, 2014 and 2016) have been strongly linked to severe damage caused directly by powerful high speed winds and hails that destroyed at least 5-10% of the mature plantation. The damage was further worsened in many places where the forest cover was very thin and removed to near complete in the steep sloping lands. The CHR forest has been negatively impacted by intensive cardamom cultivation. The species composition of CHR forest has been diluted. Three species (*Vernonia arborea, Artocarpus heterophyllus* and *Toona ciliata*) contribute more than 50% of the total individuals. Ecologically important erstwhile tree composition/species has been disappeared except few endemic and endangered species like *Actinodaphne malabarica, Saraca asoca* and *Kingeodendron pinnatum*. *Persea macrantha* is the most dominant species in the cardamom hills. Native evergreen forest trees like *Cullenia exarillata* and *Palaquium ellipticum* are vanishing fast from the cardamom hills. Frequent shade lopping of trees caused complete elimination of epiphytes which are very unique to the CHR forest. The last 25 years, the CHR forest had experienced terrific degradation which reduced its roughness (structure) and species composition (Figs. 1 & 2). Erstwhile healthy forest in the cardamom hills has become a degraded forest; therefore, they are unable to do their role ecologically and environmentally.

Past cardamom cultivars used to be seasonal and the flowering period was typical from June-September and the number of harvest was restricted to four rounds in a season. Planters were curious to have a continuous higher yield in pursuit of their economic excellence. This was achieved by the intense exploration by planters utilizing the then available genetic diversity, which ended with the identification of high yielding farmers' varieties like green gold (*Njallani*) etc. These varieties are succulent and high responsive to recurrent external chemical inputs and less shaded situation. Hence, the intact forest canopy was removed and disturbed as frequent as possible. This paved way for degradation. With respect to surface air temperature (SAT), the CHR had recorded a decadal increase of 0.3°C since 1978. The increase in mean annual (T_{min}) had been more pronounced in the night time, leading to decline in daily temperature range or diurnal temperature range (DTR). Night and day time temperature extremes along with intense surface insolation triggered both suckering and prolific tillering of cardamom all along the season. This had resulted farmers' popular varieties to have 45% more tillering along with 135% increased panicle (flower shoot) production leading to several fold increased usage of fertilizers. Therefore, most of the planters' field soils have pH values ranging between extremely acidic (3.5) and strongly acidic (5.5). Significant reduction in soil pH has occurred upon long-term application of synthetic fertilizers and chemicals in CHR soils. This had led to further increase in hydrogen ion activity manifold. Nitrogenous fertilizers are given more frequently through foliar and soil application. Application of nitrogenous fertilizer sources (Ammonium-N) regularly at the rate of 250 kg/ha can increase hydrogen activity by six fold instantly, which means an instantaneous decrease in pH by 1.0 unit. Ultimately, the soils need to be limed heavily. With all inputs the farmers' varieties have potency to out yield the older clones and now at least a four fold increased production has been realized (Table 1). Cardamom curing is a skilled process going on continuously for 150-200 days in a season. At least 1500 units are active in this task which totally consumes around 1.5 lakh tonnes of firewood on yearly basis. Therefore, this indicates that the quantum of firewood consumed seasonally to cure fresh cardamom has been increased by three fold. Other forms of energy (electric and diesel) are not preferred as they are unreliable and costly. Burning firewood produces huge CO_2 containing smoke in to the atmosphere depending on the type and quality (density) of the wood in use. The average carbon content of semi soft wood material (1 kg) ranges from 450-500g. Theoretically, burning one kg of firewood will generate 1.65 to 1.80 kg of CO_2. The CHR consumes annually 1.5 lakh tonnes of firewood which gives out huge volume of CO_2 into the atmosphere.

Table 1. Yield of cardamom (cured) from the CHR cardamom hotspots (g clump^{-1})

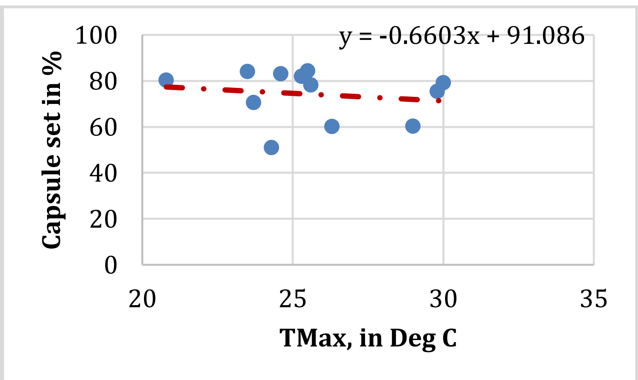
Year	Nedumkandam	Kadamakuly	Vellaramkunnu	Vazhaveedu	Mettukuzhy	Mean
1990*	374	670	511	580	572	541
2000**	582	840	742	916	610	738
2010**	1,048	1,600	1,482	1,467	1,259	1371
Mean	668	1037	912	988	814	

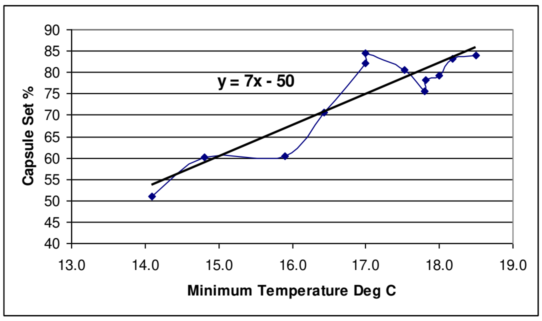
Relatively high variability of daily cycles (air temperature and relative humidity), comparing with the relatively low variability yearly cycles, is the major features of CHR climate helping both minor and major pests and diseases to be widespread throughout the season. The current high yielding varieties have robust succulent tillers that are highly susceptible to insect pests and diseases. Planters are managing these pests by several rounds of chemical treatments (18 rounds yr^{-1}). Most of the times planters use combination pesticides in cocktails. This causes serious concern over externalities and long term sustainability of the CHR system.

An increase in night time respiration rates could decrease cardamom biomass yield, but 0.3°C increase in minimum temperature over a decade did not affect the cardamom yields. Enhanced land/soil and surface air temperatures caused by forest degradation had increased the evaporation levels in cardamom hills. An increased evaporation level has been reported depending on the altitude of the stations. Across years, the summer month's evaporation levels were very high compared to rainy season months. Year to year variations were very clearly noticed during the study period**.** Increased evaporation levels were reported for lower elevation site than for high elevation station which may be due to the altitude induced lower temperature levels along with prevailing cooler condition at the montane or higher elevation sites. Under declining future rainfall scenario, higher evaporations at lower elevations may cause fast soil drying demanding early frequent irrigation and further adding on irrigation cost as well as ecosystem demand. The lower elevation sites may pump more moisture into the near surface air which may have significant influence on pest and disease prevalence. The pumped moisture can cause temporal variations in the saturation and absolute humidity levels as well as air temperature. They are all interconnected with one another (weather elements), therefore, the combined effect of land/soil and surface air warming will have an impact on the water holding capacity (WHC) of the atmospheric air as well as specific humidity (actual moisture in air). These weather factors in combination have direct influence on cardamom capsule set (Fig. 1) as well as pest's infestations (root and foliar pests). The correlation between weather elements and pest and diseases is given in Table 2.

Table 2. Climatic elements and their correlation with insect pests and diseases

Organism	Max temp (°C)	Min temp (°C)	RH (%) (morning)	RH (%) (evening)	Sunshine hours (d^{-1})	Rainfall (mm)
Insect pest						
Thrips	+ ve	NS	- ve	- ve	+ ve	- ve
Shoot borer	+ ve	NS	- ve	- ve	+ ve	- ve
Shoot fly	NS	NS	NS	NS	NS	+ ve
Red spider mite	+ ve	+ ve	- ve	- ve	+ ve	- ve
Whitefly	+ ve	+ ve	- ve	- ve	+ ve	- ve
Lacewing bugs	+ ve	NS	- ve	- ve	+ ve	- ve
Disease						
Capsule rot (*Azhukal*)	- ve	- ve	+ ve	+ ve	- ve	+ ve
Clump rot	- ve	- ve	+ ve	+ ve	- ve	+ ve
Chenthal	- ve	- ve	+ ve	+ ve	- ve	+ ve
Leaf blotch	- ve	- ve	+ ve	+ ve	- ve	+ ve
Fusarium rot	- ve	- ve	+ ve	+ ve	- ve	+ ve
Leaf rust	- ve	NS	+ ve	+ ve	- ve	+ ve





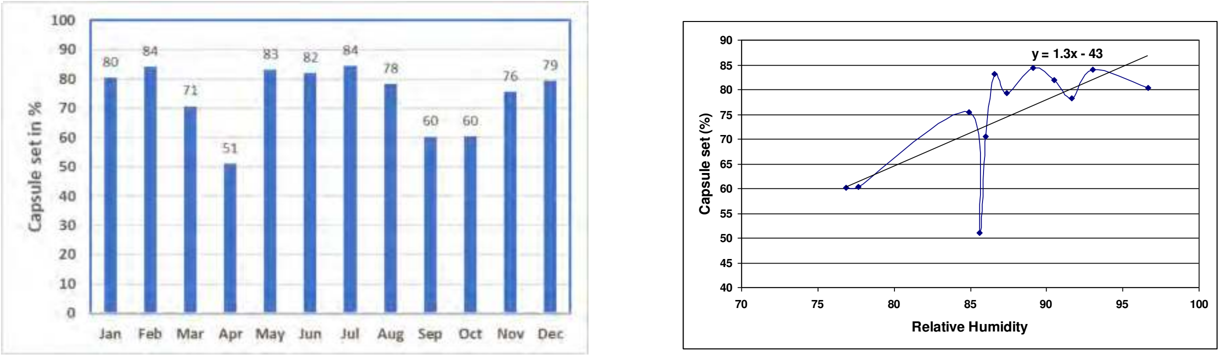


Fig. 1. Weather parameters influence on capsule set percentage

Of all climatic elements, rainfall and its distribution is the most influential factor (in cardamom cultivation) followed by surface air moisture (humidity) and microclimate (mediated by slope length and aspect). Annual total rainfall in the eastern most slopes of the CHR has been 1500 mm while the west facing slopes close to Elappara range has a maximum of 7000 mm. A greater spatial and temporal variation in rainfall has been noticed across cardamom hills. Considerable variations and reduction in the first monsoon rainfall were observed but the amount of winter monsoon rainfall were increasing during the recent years. Summer month's rainfall (Jan-May) with normal distribution has significant positive relationship with yield. Therefore, for sustaining higher yields of cardamom, summer month's rainfall and its distribution is the most important one than those of summer (June-September) and winter monsoon (October-December) rainfall. It is conspicuous that more than century scale precipitation shows decreasing trend for summer months (Fig. 2).

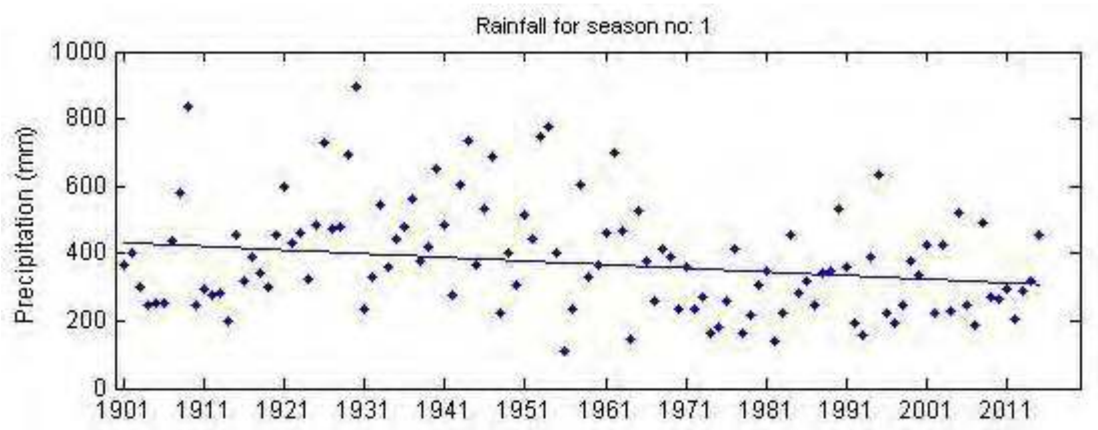


Fig. 2. Centennial trend of summer month's (Jan-May) precipitation in cardamom hills at Pampadumpara

In cardamom hills, our observation showed corresponding increase in rainfall with increase in altitude (Fig. 3). It is evident from the observed long-term precipitation data as well as future climate (precipitation) change based on inter-comparison of 36 global climate models that, variability of rainfall in smaller time-scale will be high, which means the lower elevation plantations will be exposed to severe water scarcity much more thereby increasing the cost on irrigation and cultivation. In a dry span of three months, the planters need to give a minimum of five irrigations. Further, the pressure on environmental resource (ground water) will be aggravated. Therefore, in future, the cardamom cultivation may be pushed upto the higher elevations.

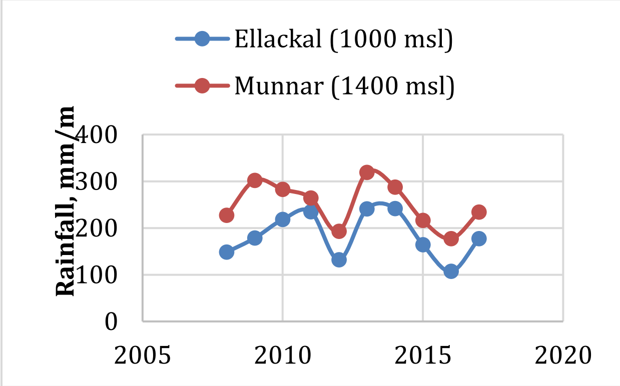


Fig. 3. Influence of altitude on rainfall in cardamom

An average increase of bright sun hours by one hour has been reported at Pampadumpara over the last two decades. Higher maxima on east facing slopes have been observed to a longer period of insolation due to a lower frequency of clouds in the morning than in the afternoon. The lower minimum temperatures experienced due to drier soils, were possibly because of greater evaporation under conditions of greater insolation. The soil temperatures on the easterly slopes upto 10 ºC warmer at 1 cm, in the morning before cloud had built up. But in the afternoon, the west facing slope was just a few degrees warmer because cloud cover reduced the warming effect of direct sunshine. Hence, the differences in the east-west aspect could be an important ecological factor in tropical mountains and the cardamom hills are no exemption.

Soil temperature data are far more important for understanding ecosystem services and processes like soil nutrient dynamics and soil microbial communities and their activities that enhances environmental quality. Surprisingly, the soil temperature data and information are very scarce in the world. Long term soil temperature research in India is very scanty; therefore, published literature is hardly available. Temporal and constant increase in soil temperatures for the top 15-20 cm soil was recorded since 1990 to 2013 at Pampadumpara agroclimatological station. The data showed abrupt increase in cumulative mean soil temperatures across seasons for the hottest years like 2002 and 2012. Considering the whole period, the highest soil temperature value was observed for March (37.1˚C) and the lowest value was 22.2˚C measured for November. During the past two-and-half decades, the summer months (January-May) have recorded higher temperatures than those of rainy season months (June-December) regardless of soil depths. Greater variations in soil temperatures occurred in the top 5 cm soil layer than the layers beneath it. Difference in soil temperature values (seasonal mean) between summer months and rainy months was of the order of 6˚C. Soil temperature values decreased with increasing in depth. Among summer months, March and April had higher soil temperatures irrespective of time period and soil depth. A significant upward trend in soil temperature at depths 5cm and 10 cm, (both with $p < 0.05$) was noticed in the last 25 years that coincides with the era of intensive soil insects infestation.

Tropical mountain locations experience strong relative humidity change through the course of year depending on the topography and vegetation as well as land use change. A strong coupling between air temperature and relative humidity plays an essential role on crop phenology and pathogenic infection on crops. Relative humidity increased at Pampadumpara station during the study period for all three seasons. Monthly relative humidity increase was greater for April followed by March and October. The least increase was noticed for August and June. A wider fluctuation was found in winter monsoon (October, November and December) from 1980 through 1990 and then from 2000 through 2007. Monthly relative humidity increase was greater for April followed by March and May and December. Wider fluctuations in relative humidity were observed during winter monsoon months from 1991 to 1995 and from 2000 to 2006. Vandiperiyar station reported both increasing (for season 2 and 3) and decreasing (season 2) trends. Increased relative humidity levels were reported for summer months (January to April) and decreased trends followed later for months from June to December. Varying levels of relative humidity were observed around 1997-2002 for the first monsoon months (June-September). Larger fluctuations were experienced for winter monsoon months (October-December) mainly during 1990-1995 at Vandiperiyar. These variations may be due to change in the roughness, rainfall amounts and distribution as well as irrigation.

Future temperature and precipitation change based on RCP 4.5 and 8.5

The results of the inter-comparison of 36 global climate models showed that the temperatures in the region consistently increased causing significant challenges in water management. Increasing temperatures could further stress groundwater reservoirs, leading to withdrawal rates that become even more unsustainable. Precipitation amounts vary greatly in all cardamom growing areas which imply that the future cardamom plantations in water resource poor areas may be affected more frequently. Therefore, production in these areas will be reduced significantly under future change scenario. In future, these results could be used to access both mitigation and adaptation alternatives to reduce vulnerabilities in managed ecosystems (agriculture and urban systems) and water resources.

Conclusion

The positive influence of climate change in cardamom cultivation is that it has helped to increase yield and productivity of cardamom by several times. The CHR forest has substantially lost its biodiversity, structure and function. Only three species contribute more than 60% of the total individuals in the CHR forest. Epiphytic diversity has been missing by at least 95% from the CHR forest. Cardamom genetic diversity has been completely vanished from the planters' field; therefore, the so called global cardamom hot spot (CHR) is not so rich in genetic diversity. Soil health and quality has been deteriorated due to chemicalized cardamom farming. Cardamom cultivation in CHR has invited more pest and disease problems which has become a menace. Planters perceive that immersing the cardamom plantation in chemical pesticides is inevitable so as to control the pests and diseases. If this is the case, the queen of spices (cardamom) will become the king of pesticide consumption and will change the land of spices in to the land of poisons. The cardamom farming has escalated its cost of production by many folds resulting ever declining net profit which means that attainability of economic sustainability is seemingly unlikely. It is therefore recommended for future that energy transfers (thermodynamics) in CHR ecosystem processes must be studied for improving the agricultural sustainability of cardamom cultivation.

ORAL PRESENTATIONS

OP13

Epidemiological parameters to delineate weather-disease interaction and host plant resistance in small cardamom

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Small cardamom, the versatile spice of Zingiberaceae is cultivated in diverse agro-climatic regions in India. Leaf blight incited by divergent species of *Colletotrichum* is one among the major challenges encountered across different cardamom growing tracts. In the present investigation, epidemiology of cardamom leaf blight was studied and an attempt was made to decipher the resistant nature of Malabar, Mysore and Vazhukka genotypes based on epidemiological parameters. The average percent disease index recorded in Malabar, Mysore and Vazhukka varied from 23.41 to 27.72, 18.79 to 20.34 and 18.74 to 20.38, respectively during October, 2015 to September, 2016. The disease exhibited a positive correlation with respect to T_{max} and T_{min} in all the genotypes, however, significant correlation was observed only in Malabar and Mysore with respect to T_{max}. Whereas, rainfall and rainy days had negative correlation with the disease in all genotypes however, found to be non-significant. In general, the apparent infection rate (r) was negative during May to June indicating the occurrence of anti-epidemics. The average infection rate was maximum (0.000429) in Malabar, whereas it was 0.000124 and 0.000186 in Mysore and Vazhukka, respectively. The area under disease progress curve registered the highest for Malabar (8814.15) and lowest in Vazhukka (6531.02) while, Mysore type recorded 6612.96 indicating that, Vazhukka and Mysore types might possess horizontal resistance and Malabar with vertical resistance. In the light of above results, plant protection measures could be scheduled based on the take-off level and genotypes with horizontal resistance could be promising candidates in resistance breeding programmes.

OP14

Trends in chilli production and productivity in relation to weather parameters in Guntur district of Andhra Pradesh

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India is the largest producer, consumer and exporter of chilli and contributes 25% of total world production. Andhra Pradesh ranks first in area, production and productivity of chilli contributing 30% of the total area and 51% of total production. The present study was conducted for assessing the influence of weather parameters from 1999 to 2017 on chilli production and productivity in Guntur district, Andhra Pradesh. Correlation of weather parameters with production and productivity was done based on rainfall pattern (*i.e.* the years where annual rainfall was <750 mm, 750-1000 mm and rainfall >1000 mm). The study revealed that, when rainfall was less than 750 mm, temperature (maximum and minimum) and relative humidity had negative correlation with production and productivity, whereas, rainfall had significant positive correlation. Temperature

showed significant positive correlation with production and productivity during the years when annual rainfall was >750 mm. However, rainfall and relative humidity showed significant negative correlation with production and productivity when the annual rainfall was >1000 mm. The study indicated the impact of weather conditions on production and productivity of chilli in Guntur district of Andhra Pradesh and may help in developing forecasting models based on climatic conditions.

OP15

Trends in area, production and productivity of spice crops in North Eastern region

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The present study was undertaken to analyze the trends in area, production and productivity of major spice in North Eastern region. The study was based on secondary data spanning thirty six years from 1981-1982 to 2017-2018 collected from several government publications and web sites. To analyze the trends in area, production and productivity linear, quadratic and exponential functional forms were used. To fit the trend, exponential functional form was used due to its higher R^2 value as compared to other two forms. Besides these, compound growth rate, coefficient of variation and instability index were also estimated. The effects of area, productivity and their interaction towards increasing production were also estimated. The study indicated that, growing spice crops is not risky in the North Eastern region as revealed by low coefficient of variation. The coefficient of variation for area, production and productivity of spice crops was less than 4.16%. The instability indices for area, production and productivity for spice crops were positive thereby indicating less risk for growing spice crops in the region. The increase in production is due to increase in area as well as interaction of area and productivity of spices in the region.

SESSION III c:
TECHNOLOGY-LED ORGANIC PRODUCTION OF SPICES AND SAFE FOODS

LEAD LECTURES

Plant health management strategies for organic spices development in North Eastern Region

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Introduction

India has been referred to as a 'land of spices 'and the North Eastern Region (NER) comprising of the eight states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura) is home for major Zingiberaceous spices namely ginger, turmeric and large cardamom. Spices being used as medicine is cultivated in a natural way especially in the northeast and the region is considered as "Organic by default ". However, Sikkim has been declared as organic state and others are in the anvil. To get a healthy crop the soil must also be healthy. Over the years the soil health status both in terms of physical and biological has been deteriorating. Soil borne diseases are major production constraints and the organisms include Oomycetes, *Ralstonia solanacearum* and plant parasitic nematode *Meloidogyne incognita* for most of the major spice crops. While attempting to produce in an organic system, all the components have to be analyzed and understood and a clear idea has to be transferred to the end user the farmer. Integrated management must also address the health of the plant that basically encompasses all ecological factors including soil, nutrient availability and climatic factors. In perennial cropping system, changing whether plays a major role in predisposing the plant to infection by pests and pathogens. All these factors need to be addressed to raise a healthy crop.

Major spices in the NER

North eastern India is known for the Geographical Indications (GI) marked spices and has been registered with the GI Registry, like the highly pungent chillies like Naga Mircha (Appln. no.109); Mizo chillies (Appln. no.377); Assam Karbi Anglong ginger (Appln. no.435) and high oleoresin containing golden spice turmeric. As per the production figures, during 2015/16 black pepper was grown in an area of 129130 ha of land in India with a production 65680 tonnes; ginger in 161670 ha with a production of 1087560 tonnes; Chilli in 817390 ha and a production of 1516090 tonnes; and turmeric 185580 ha with a production of 943330 tonnes (Source: DASD). The National Production statistics does not mention all the states individually in the north east contributing to the total production indicating that there is no substantial production though it is cultivated in certain pockets. For example, production figures for black pepper has no mention about Assam (table 1). There is a great potential to grow other spices like black pepper, cinnamon, nutmeg and garcinia in these areas.

Table 1. Area and production of some spices in the Northeast

Crop	State	Area (ha)	Production (tonnes)	Total area (ha)	Total production (tonnes)
Large cardamom	Sikkim	22755	3744	26060	4465
	West Bengal	3305	721		
	Total including other states	26060	4465		
Turmeric	Assam	16309	15792	207570	1092628
	Mizoram	6050	22990		
Total including other states					
Ginger	Arunachal Pradesh	7000	57000		
	Assam	15683	122307		
	Meghalaya	9642	62994		
	Mizoram	7280	28390		
	Sikkim	9300	52110		
	Total including other states			138200	683160
Black pepper	Karnataka	27955	16000		
	Kerala	84065	20000		
	Tamil Nadu	4300	1000		
	Total including other states			122400	37000

Source: DASD; Spices Board

Organic production

Organic production systems are defined by National Organic Standards Board as “an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, and enhance ecological harmony”. An organic production system is a holistic food production management system, which results in sound agroecological health, combat climate change, enhanced biodiversity and soil biological activities and involves nutrient cycling, optimize plant and animal health, and increase resource efficiency in agricultural ecosystems. There are several certifying agencies within the country and globally that follows the set standards and there is provision for Internal control system that is audited by the certifying agencies for a fixed fee.

Production constraints

The major production constraints are the crop losses caused by pests and pathogens. The major diseases of the spice crops of NER are listed in table 2. In spice growing areas there is a gradual decrease in productivity mostly due to soil factors such as reduced nutrient availability due to pH related issues, reduced soil organic matter, availability of water, damages due to pest and diseases. The imbalance in nutrients, are some of the limiting factors. Deteriorating soil health, water and nutrient availability, excess moisture during monsoon are some of the predisposing factors. Before attempting to address the pests, it is necessary to ensure all soil factors are favourable for availability of nutrients so that the plant is healthy. In this lecture the major diseases, affecting spice crops in the region and the management strategy are discussed.

Table 2. Major diseases of the spice crops in NER

Crop	Disease	Causal organism
Large cardamom	Chirkey -Mosaic Foorkey- Bushy stunt Leaf blight	Virus Virus *Colletotrichum gloeolsporioides*
Ginger	Rhizome rot	Pythium aphanidermatum *P. myriotylum*
	Ginger yellows Bacterial wilt	*Fusarium* spp. *Meloidogyne incognita* *Ralstonia solanacearum*
Turmeric	Rhizome rot	Pythium graminicolum
Black pepper	*Phytophthora* foot rot Slow decline	*Phytophthora capsici* *Radopholus similis* *Meloidogyne incognita*

Integrated disease management

Epidemiology is the science dealing in understanding the disease but its proper management is a skillful art. Unless the plant health is ensured managing the disease becomes difficult. The integrated disease management (IDM) includes the cardinal principles of avoidance, eradication, deploying resistance sources and finally management. Under management cultural, biological and chemical are integrated. The IDM consists of timely application of a combination of strategies such as, land selection and preparation, deploying resistant sources if available, modifying the micro-environment, providing adequate drainage to prevent water stagnation, optimizing irrigation, canopy management and need based application of chemical pesticides. But in addition to these measures, managing the soil factors like, soil pH, nutrients, and organic carbon content are important. Application of balanced nutrition as per the crop phenology will help promote healthy and vigorous plants. In organic production system where external inputs are minimized to essential inputs, it is all the more essential to manage the soil fertility to ensure microbial activity thereby ensuring natural biological control.

Unique adaptations in soil borne pathogens

Compared to foliar pathogens, managing soil-borne pathogens offers difficult preposition. There are many important differences in the ecology, epidemiology, life cycles, pathogenesis, and infection process by root pathogens as these pathogens do not have the high degree of host specificity that characterize most biotrophic foliar pathogens. Most root pathogens are necrotrophic, that is, they kill host tissue with toxins, peptide elicitors, or enzymes that trigger host cell lysis and death, thereby providing conditions favorable to pathogen growth. The classic examples is species of *Pythium* that affects both ginger and turmeric. *Pythium* show a preference for young, juvenile tissue as compared to older woody tissues with secondary wall thickenings, and can attack germinating seeds in the soil, causing pre- or post-emergence damping-off or seedling rot. They also can attack young root tips and feeder roots, since the newest tissue is formed at the root tip by penetrating root epidermis. These pathogens produce thick-walled resistant survival structures that are capable of surviving environmental extremes in a dormant state in the absence of a susceptible host. Among the pathogens that parasitize root systems a few are biotrophic, that is, they require a living plant to parasitize and obtain nutrients from it such as *Phytophthora sojae*. It is hemi-biotrophic and form haustoria or feeding structures in plant cells. Another characteristic of most root necrotrophic pathogens is their wide host range. In contrast to biotrophic pathogens, the majority of root necrotrophic pathogens do not appear to have closely coevolved with a specific host, or to be distinguished by races that are virulent on specific genotypes, varieties, or cultivars of domestic plants.

Adaptations to adverse conditions in Oomycetes

The life cycle of necrotrophic root rotting soil-borne pathogens involves dormant propagules when environmental conditions are not suitable for growth, or when the host is not present. They must also withstand microbial degradation and lysis, parasitism and predation, constituting an important trophic level in the soil ecosystem. Therefore, in many pathogens, a thick-walled resistant spore or structure has evolved to serve this survival function. In the case of *Pythium*, sexual spores called oospores, or thick-walled sporangia serve this purpose. These structures are formed in rotting root tissue, which can also offer a degree of protection. This is an important factor to be considered while attempting biological control. Once environmental conditions become favorable and a root emerges or grows in close proximity to the fungal propagule, the resistant structure will germinate to form hyphae that will grow toward the susceptible root or seed. If conditions are wet enough, *Pythium* will form zoospores, motile flagellated spores that swim in the film of water around soil particles and contact the root. These pathogens have mechanisms of chemotaxis and chemotropism and sense root exudates such as sugars, amino acids, organic acids and fatty acids and grow in response to gradients of these compounds. Electrostatic charge may also be an important sensory stimulus for swimming zoospores and are often attracted to the zone behind.

Opportunistic adaptation in *Ralstonia*

The bacterial pathogen *Ralstonia solanacearum* is unique in having a host range of over 200 species belonging to 50 families. It has evolved mechanisms for living outside the host and maintains its population by quorum sensing, gains entry through wounds and opening created by root branching thereby eluding host detection. Once inside it is capable of dissolving host cell wall and possess complex secretary system that helps in pathogenesis.

Outsmarting soil-borne pathogens

In order to overcome the fore mentioned mechanisms of soil-borne pathogens, several attempts have to be made to reduce the inoculum load. Temperature is one of the methods to destroy the resting pathogen propagules. Perhaps for ages it was followed in the North East by following *Jhum* cultivation and other methods of cultivation to raise the soil temperature before planting ginger.

Soil solarization: In this method the solar heat is trapped to increase the soil temperature by covering the seed beds or planting beds with a clear polythene sheet and sealing the sides with mud. The temperature could be about 10-15°C more than the ambient temperature. The moisture in the soil makes the propagules and weed seeds to germinate and the heat generated during the day time kills the germinated propagules. As the process is continued for about a month, the dormant propagules germinate and are eliminated by the heat.

This process eliminates heat sensitive organisms both beneficial and harmful. Hence artificial inoculation of beneficial organisms along with organic matter like compost is recommended to benefit from soil solarization.

Biofumigation: An alternative to chemical fumigation with chemicals such as methyl bromide is available for ecofriendly organic way of eliminating pathogen propagules. Plant refuse from crucifers contain glucosinolates in the foliage. This on action by myrosinase enzyme releases glucose and isothicyanates that is toxic and has fumigant action. Although the quantity released is smaller, by combining with soil solarization the rhizome rot of ginger was managed in diseased fields. This was confirmed in various locations in the All India Coordinated Research Project on spices. This is an improved version of crop rotation suggested and followed for ages. In areas suitable for cultivation of cruciferous vegetable crops during winter months this would be an ideal crop rotation and the crop residues can be incorporated to soil and fumigated before using this land for cultivating crops like ginger that is susceptible to *Pythium,* the soft rot pathogen.

Biological control

Microorganisms constitute one of the major components of the biosphere that sustain the nutrient cycling on this planet. Although less than one per cent is cultured, a tremendous diversity exists in the populations. Latest molecular techniques enable Scientists to understand and appreciate the diversity and help to utilize the beneficial effects of microbial diversity for increased productivity. Among soil organisms, intense activity is found in and around rhizosphere of plants because of the presence of the secreted nutrients such as carbohydrates, amino acids and other cellular components present at the growing tip of roots. These root colonizing microorganisms form symbiotic, associative, or parasitic relationship with the plants. These organisms have evolved mechanisms to occupy and reside in the specialized niche. These mechanisms are often utilized both for growth enhancement and disease suppression. The host also plays an important role in selecting its own microflora for the rhizosphere similar to the probiotic microflora of human gastrointestinal tract.

Biological control is a meek attempt to mimic the natural situation by using one organism or a material derived from one organism to regulate the population of another usually the harmful disease-causing organisms. In natural habitats both pathogens and their biocontrol agents live in harmonious balance. But in agricultural soils due to preferential cultivation of desired plants there is a disturbance to the soil ecology and the fluctuation in the microbial communities.

Trichoderma as biocontrol agent

Species of *Trichoderma* are conspicuous for their ubiquitous distribution, dominance over other soil fungal communities. Their nutritional requirement is minimal and they produce abundant propagules, which include mycelium, conidia, and quiescent resting spores, which grow upon availability of nutritional source. They are adapted to survive in varied habitats such as decaying wood, cotton fabrics and aerial and subterranean plant parts. In order to survive in such varied habitats, they are endowed with superior competitive nature and possess an arsenal of cellulolytic enzymes. Their ability to produce various volatile and non-volatile metabolites makes them efficient antagonists for several pathogens of agricultural crop plants. The high degree of ecological adaptability, the ability to grow on inexpensive substrates makes *Trichoderma* amenable for mass multiplication and manipulation for various formulations and delivery systems. All these characters render *Trichoderma* species as successful biocontrol agents.

Other root colonizers

Among the root inhabiting organisms, fluorescent pseudomonads constitute some major successful colonizers followed by bacilli. The commonly occurring species include *Pseudomonas fluorescens, P. putida* and *P. aeruginosa.* It was Kloepper & Schroth (1978) who reported that certain root-colonizing bacteria could promote radish growth in greenhouse and field trials and named the bacteria plant growth-promoting rhizobacteria (PGPR). Since then a large number of scientists have been involved in the research on PGPR all over the world. The endophytic nature of some PGPR makes them suitable for use in vegetatively propagated crops because of their capability to colonize and persist within the plant system. PGPR have been used as biological control agents for the suppression of soil-borne diseases by competing with pathogens for resources such as nutrients, producing antibiotics or activating host defense mechanisms. These organisms often bring about the growth effects synergistically.

Mechanism of root colonization

The activity of microbes is intense where nutrients are available. The rhizosphere of plants is one such active zone. There is stiff competition for this niche both by saprophytes and pathogens. Rhizosphere colonization is considered as the basic step for both root invading soil borne pathogens and surface colonizers. The understanding of root colonization is important for various applications such as biofertilization, biocontrol, biostimulation and bioremediation. Along root colonizing bacteria *Pseudomonas* has been rated at the top. Root colonization is studied using several techniques. The important being confocal laser scanning microscopy, green fluorescent pigment (gfp) in gnotobiotic systems. Fluorescent pseudomonads being efficient colonizers have been studied intensively. Competitions among fluorescent pseudomonads also occur as revealed by studies involving mutants.

Mode of action of fluorescent Pseudomonads

The mode of action involves both direct and indirect mechanisms. The direct mechanisms are growth stimulation by their metabolites that serve as growth hormones and by improving nutrient availability. The indirect methods are through competition by decreasing the activities of pathogens through action of antibiotics, siderophores and Hydrogen cyanide. Most of Pseudomonads produce antibiotics, enzymes, and other metabolites antagonistic to many plant pathogens. The activities of growth promotion and disease suppression is considered as both sides of the coin as the isolates selected for biological control often show enhanced growth.

In case of spices several *Pseudomonas* isolates have been obtained from black pepper and ginger and screened for their ability to suppress pathogens and some were short listed for their antagonistic activity on both oomycetous pathogens and nematodes. These isolates were also found to enhance growth of the host plants. In case of spices, a large numbers strains of *Pseudomonas fluorescens* have been isolated, screened and strains that are effective against soil borne pathogens were short listed and tested for their mechanisms.

By inducing defense in plants

One of the first published reports of systemic resistance in plants was by Chester (1933), who used the term "acquired physiological immunity". It has been reported that tobacco plants exhibit "systemic acquired resistance" following local infection with tobacco mosaic virus. Other terms that have been used to describe systemic resistance in plants include "translocated resistance", "plant immunization", and "induced systemic resistance". Induced Systemic Resistance (ISR) is a process of active resistance dependent on the host plants physical or chemical barriers activated by biotic or abiotic agents. Localized treatment of plants with specific biotic or abiotic agents can result in the development of enhanced resistance against pathogens in distal plant parts. Resistance induced by such treatments is generally characterized by a restriction of pathogen growth and a reduction of disease severity. Rhizobacteria-mediated ISR has been demonstrated to be effective in a variety of plant species under conditions in which the rhizobacteria remained spatially separated from the challenging pathogen. It has been demonstrated in *Arabidopsis* that volatile organic compound such as 2, 3 butanediol activate ISR. This signaling pathway is dependent on ethylene independent of SA and JA pathways. There is accumulating evidence to suggest that beneficial microorganisms trigger the immune responses of plants.

Significant advances in the elucidation of mechanisms involved in plant growth promotion have been made, especially when using molecular biology approaches. Mechanisms include mainly the role of biological nitrogen fixation, production of phytohormones and biological control. The positive effects of PGPR are mainly due to morphological and physiological changes of the roots of inoculated plants, which lead to an enhancement of water and mineral uptake, especially when plants grow in sub-optimal conditions. Indeed, inoculation with PGPR increases the density and length of root hairs, as well as the appearance and elongation rates of lateral roots, thus increasing the root surface area. These effects are linked to the secretion of plant growth hormones such as auxins, gibberellins and cytokinins by the bacterium. The dynamics of colonization of plant surfaces by the beneficial bacteria and the rhizosphere ecology has also been investigated. The effect of these beneficial microbes being stimulated by root exudates, and, in turn, decreasing the incidence of plant pathogens is so well recognized that inoculation of plants in the field and greenhouse is becoming a cheap and effective pathogen biocontrol method.

Delivery of biocontrol agents (BCAs)

Traditionally, efficient microorganisms are mass multiplied and distributed to farmers using several inert materials like talc or on grains or in agricultural bye products coffee and tea wastes. Most of the commercial products are distributed this way besides other formulations like water or oil based. The major drawbacks are the shelf life of the product and bulkiness.

Novel delivery methods for beneficial microbes

Two novel methods of delivery of beneficial microbes have been developed and applied for Indian patents; one is on delivering the PGPR on the seed itself called as seed coating (Patent 1: 4465/CHE/2013 dated 01/10/2013 A seed coating composition and a process for its preparation) and a novel method of storing and delivering PGPR/microbes through biocapsules (Patent 2: 3594/CHE/2013 dated 13/08/2013).

The PGPR formulation as biocapsule is an easy and reliable technology of storing and delivering PGPR bioagents in hard gelatin capsule termed as biocapsule. It is a preparation of viable microbial agents in a capsule form. Initially, this technology was developed using efficient plant growth promoting rhizobacteria (PGPR) for ginger namely *Bacillus amyloliquefaciens* GRB35. Based on extensive field studies and monitoring the shelf life for over 18 months patent application was filed. In this method, the shelf life of the bacteria is maintained and cell number is further enhanced before application in the field by activating the culture for twelve hours, diluted and applied. The method is available for delivering both bacteria and antagonistic fungus like *Trichoderma harzianum*. This technology has been commercialized to several entrepreneurs by ICAR-IISR, Kozhikode.

Conclusions

Plant disease management strategies aims at exploiting the natural defense mechanisms in plants by deploying the resistance genes and activating the natural defenses besides following a set of cultural practices. Soil borne pathogens elimination is a difficult task and is possible by following the traditional methods with modernization. The burning of refuse before planting ginger is a traditional method but the scientific principle is to eliminate/reduce pathogen population. The second line of defense being integrated disease management where biological control organisms are introduced. Growing knowledge on the role of beneficial microbes in triggering defense mechanism in host plants offers additional impetus for shifting from chemicals to more ecofriendly methods involving biological control agents. The rhizosphere of plants plays an active and decisive role in the selection of its microbial communities. The soil borne pathogens have to face a different microbial environment in the bulk soil and in the rhizosphere as it involves the live host plant and its own microbes influenced by its exudates. The soil being a complex and dynamic structure the suppression of pathogens depends up on various factors. The health of the plant depends on the health of the soil and the nourishments the plant obtains from a healthy soil for vigorous growth. A thorough knowledge on the ecology and interaction of the introduced biocontrol agent with other components in the soil and rhizosphere will go a long way in achieving the desired results.

Organic farming in India: Ensuring integrity

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The concept of organic agriculture is very much native to this land. Whosoever tries to write a history of organic agriculture will have to refer India and China. The farmers of these two countries are farmers of 40 centuries and it is organic agriculture that sustained them. In broad sense, organic farming means "farming in spirits of organic relationship". It is based on a system-oriented approach and can be a promising option for sustainable agricultural intensification in the tropics, as it may offer several potential benefits such as: (i) Greater yield stability, especially in risk-prone rainfedtropical ecosystems and hill farming, (ii) higher yields and incomes in traditional farming systems, once they are improved and the adapted technologies are introduced, (iii) improved soil fertility and long-term sustainability of farming systems, (iv) reduced dependence of farmers on external inputs, (v) restoration of degraded or abandoned land, (vi) the access to attractive markets through certified products, (vii) new partnerships within the whole value chain, as well as a strengthened self-confidence and autonomy of farmers and (viii) chemical residue free safe and healthy food for consumers.

Realizing the benefits of organic food, consumers are also demanding organically grown food and fiber and are willing to pay premium prices. But to tap the market there is an inevitable need for the production system to comply with the set rules of production, processing and handlingand to ensure the integrity throughout the value chain there is also an inevitable need for certification. Recently regulations have also been enacted to ensure that only the genuine organic products, complying the certification systems, reach the shelves of retail stores.

Regulatory system for organic food in India

The Food Safety and Standards Authority of India (FSSAI) the main regulatory body for food safety and standards has brought organic food under the ambit of Food Safety and Standards Act 2006 through the Food Safety and Standards (Organic Food) Regulation 2017. These provisions shall be mandatory with effect from 1st July 2018.

Salient features of the regulation are as follows:

1. **Basic mandate -** No person shall manufacture, pack, sell, offer for sale, marketor otherwise distribute or import any organic food unless they comply with the requirements laid down under theseregulations.

2. **Applicability of the systems** -(a) The organic food offered or promoted for sale shall also comply with all theapplicable provisions of one of the following systems, namely:
    - (i) National Programme for Organic Production (NPOP);
    - (ii) Participatory Guarantee System for India (PGS-India).
    - (iii) Any other system or standards as may be notified by the Food Authority from time to time.

    (b) The organic food which is marketed through direct sales by the small original producer or producerorganization, as determined by the Food Authority from time to time, to the end consumer shall be exempted from the provisions of the systems referred above at 2.

3. **Labelling -** (a) Labelling on the package of organic food shall convey full and accurate information on the organic status of the product. Such product may carry a certification or

quality assurance mark of one of the systems mentioned at 2 above in addition to the Food Safety and Standard Authority of India's organic logo.

(b) All organic foods shall comply with the packaging and labeling requirements specified under the Food Safety and Standards (Packaging and Labelling) Regulations, 2011 in addition to the labelling requirements under one ofthe applicable certification systems mentioned at 2.

4. **Traceability**–Traceability shall be established upto the producer level as applicable under the systems mentioned in the regulation and it shall include any other requirements prescribed by the Food Authority to maintain the organicintegrity of the food product.

5. **Requirement to comply with the provision of the other regulations made under the Act** - Without prejudice to the provisions of these regulations, all organic food shall comply with the relevant provisions, as applicable, under the Food Safety and Standards (Food Product Standards and Food Additives) Regulations, 2011. The organic food shall also comply with relevant provisions, as applicable under the Food Safety and Standards (Contaminants,Toxins and Residues) Regulations, 2011 except for residues of insecticides for which the maximum limits shall be 5% of the maximum limits prescribed or Level of Quantification (LoQ) whichever is higher.

Organic certification

Organic certification is a process certification intended for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers (crop, livestock),food processors, retailers and restaurants. Requirements vary from country to country, and generally involve a set of production standards for growing, storage, processing, packaging and shipping that include:

- Avoidance of synthetic chemical inputs (e.g. fertilizer, pesticides, hormones, antibiotics, food additives, *etc*) and genetically modified organisms;
- Use of farmland that has been free from chemicals for a number of years (often, two or more);
- Keeping detailed written production and sales records (audit trail);
- Maintaining strict physical separation of organic products from non-certified products;
- Undergoing periodic on-site inspections.

Organic certification systems in India

Currently India has two types of certification systems:

(a) **National Programme for Organic Production (NPOP)** - India is among the first few developing countries to have developed and launched a credible third party certification system. NPOP was launched during 2000 for export of organic commodities, but now it is also applicable for import and domestic market under the ambit of FSS Act 2006. Twenty eight accredited certification agencies authorized under the programme are certifying organic producers. The certification system under NPOP is internationally acclaimed and has recognition agreement with European Union, Switzerland and USA. NPOP is being operated by the Ministry of Commerce and Industry with APEDA as its secretariat.

(b) **PGS India** – To make the certification system affordable and to make the farmers as partners in the quality assurance initiative a farmer group centric certification system under PGS-India programme was launched under National Project on Organic Farming by the Ministry of Agriculture, Cooperation and Farmers Welfare with National Centre of Organic Farming (NCOF) as its secretariat.Organic certification under PGS India programme is a Participatory Guarantee System with its applicability to local and domestic markets. Only group of farmers and farming/food processing operations taken up by the grower groups on-farm or under their supervision are covered under this system.

Salient features of two certification systems

Although both the systems of certification are based on the National Standards of Organic Production (NSOP) notified under National Programme for Organic Production, but have different approach for process verification, documentation and grant of certification. While NPOP system involves the participation of an independent third party, known as certification agency, the PGS India system is operated by the group of farmers away from the requirement of independent third party. Salient features of the two systems are given below:

a. NPOP-Third Party Certification - Third-party certification is a system of process certification wherein an independent organization reviews entire production, processing, handling, storage and transport *etc*. to ensure the compliance of organic standards. The process typically includes comprehensive review of cultivation practices including land management, usage of inputs, use of machinery, pest management and post harvest and processing through document review and on-site physical inspection.

***Certification process* -** Third party certification process starts with the adoption of National Standard of Organic Production (NSOP) on farm, followed by the registration of production unit with one of the accredited certification body. Ministry of Commerce, Government of India has accredited 28 certification bodies for granting organic certification. Producers can choose any one of them for their farm certification. Crop production, wild harvest collection, livestock, aquaculture, apiculture, food processing and handling, animal feed processing and handling, mushroom production, sea weeds, aquatic plants and green house crop production are the scope categories for organic certification.

In order to certify a farm operation, the producer is typically required to engage in a number of new activities, in addition to normal farming operations, which includes:

- **Study** the organic standards, which cover in specific detail what is and what is not allowed for every aspect of farming, including storage, transport and sale.
- **Compliance** - farm facilities and production methods, processing and handling, transport and packaging must comply with the standards, which may involve modifying facilities, sourcing and changing suppliers, *etc.*
- **Documentation** - extensive paper work is required, detailing farm history and current set-up, and usually including results of soil and water tests in crop and livestock production and processing facilities, processing methods and use of additives/preservatives *etc.* in processing.
- **Planning** - a written annual production/processing/handling plan must be submitted, detailing everything from seed to sale: seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, post harvest, processing, handling *etc.*
- **Inspection -** annual on-farm/processing and handling facility inspections are required, with a physical tour, examination of records, and an oral interview.
- **Fee** – A fee is to be paid by the grower to the certification body for annual surveillance and for facilitating a mark, which is acceptable in the market as symbol of quality.
- **Record keeping** - written, day-to-day farming and marketing records, covering all activities, must be available for inspection at any time.

b. PGS India–Certification under PGS-India programme is based upon the fundamental principles of Participatory Guarantee System involving participatory approach, a shared vision, transparency and trust. All the activities and decision making process is shared by the farmers themselves in a participatory mode and on cross verification of each other's process they certify their operation collectively as compliant to organic standards. Documentation requirements are very simple and restricted to peer evaluation sheets. Under PGS-India programme, although group of farmers is the main decision making body but their decision need to be endorsed by a local Regional Council duly authorized by the PGS-India secretariat. Essential steps in PGS-India certification system are as follows:

- Farmers are organized in to a group comprising of members belonging to single or nearby villages
- Members take a pledge to follow standards and follow the certification process
- Members distribute certification activities among themselves and follow the procedures
- During cropping season, a committee comprising of 2-3 members evaluates each and every member for compliance of its production system to standards.
- After completion of peer evaluation the entire group decides on the certification of each member and prepares a certification document, which is sent to the local Regional Council with certification recommendations.
- Regional council on being satisfied with the recommendations can endorse the certification decision and each and every member of the group is granted with individual certificate.
- Individual farmers, processors and traders are not eligible for certification under PGS India programme.
- Only the farming operations under group and on-farm processing activities including processing under hired facilities but under the direct control and supervision of group are certified.

Comparison of two certification systems

NPOP	**PGS**
Based on National standards (NSOP)	Also based on NSOP
Exhaustive documentation and third party verification	Simple documentation Verification by group members, RC is facilitator
Procedures widely accepted in international trade	Not accepted PGS systems are emerging
Ensures traceability end-to-end	Ensures traceability up to farm gate
Cost intensive	Low cost
Applicable for individuals, grower groups, processing facilities, organized processing units, traders, handlers and exporters	Applicable only on grower groups Individual producer, processors and trading activity not covered
Certifies crop, wild harvest, livestock, aquaculture, mushrooms, aquatic plants, food and feed processing	Only crop production and related processing till farm gate
Annual system plan based – which has to be pre approved	No provision
Exhaustive documentation on operation	Not required
Grower groups undertake 100% internal inspection	100% peer review by group member
Internal decisions by ICS members	All decisions by the group as a whole

Physical verification by independent auditor from CB	No provision
Exhaustive inspection report made by external inspector	Peer review checklist made by the group
Inspection report is reviewed by independent reviewer at CB	No provision
Decision taken by other person of CB	Decision taken by group is endorsed by Regional Council with out any verification
Certificate issued by third party	Certificate issued by local Regional Council
Chain of custody tracked through transaction certificates	No provision

Epilogue

Demand from consumers for the safe and healthy food is driving the organic farming and food industry and consumers are willing to pay the premium, provided the integrity is ensured. To safe guard the interest of the consumers and to prevent fraud and cheating, certification systems have been put in place. Regulatory provisions have now made certification mandatory.

Armed with robust regulatory provisions and credible certification system, organic farming is poised to grow in the decades to come. Today it may be just 1% of the total food production in India and world over but it is growing at a CAGR of 12-15% globally. Domestic market for organic food in India is growing at a CAGR of 15-25% and offer bright future for the organic farming in the country.

PGS India system has empowered the farmers with the entire decision making in their hands and has opened the door for them to become organic farming entrepreneurs.

Technology led organic production of spices in Sikkim

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Introduction

Currently, 43.7 million hectares area (0.99% of total agricultural land) is under organic agricultural management worldwide (FiBL and IFOAM, 2016) and India ranks no. 1 in terms of number of organic producers *i.e.*, 585,000 (FIBL and IFOAM, 2017). The total area under organic certification in India was 5.71 million hectare during 2015-16. This includes 26% cultivable area with 1.49 million hectare and rest 74% (4.22 million hectare) forest and wild area for collection of minor forest produces. India produced around 1.35 million MT (2015-16) of certified organic products which includes all varieties of food products namely sugarcane, oil seeds, cereals and millets, cotton, pulses, medicinal plants, tea, fruits, spices, dry fruits, vegetables, coffee *etc*. The total volume of export during 2015-16 was 263687 MT. The organic food export realization was around 298 million USD. Organic products are exported to European Union, US, Canada, Switzerland, Korea, Australia, New Zealand, South East Asian countries, Middle East, South Africa *etc*. Oil seeds (50%) lead among the products exported followed by processed food products (25%), cereals and millets (17%), tea (2%), pulses (2%), spices (1%), dry fruits (1%), and others (Source: www.apeda.gov.in). Globally organic produce market is increasing which is around 75 billion Euros (FIBL and IFOAM, 2017).

India is the major producer, consumer and exporter of spices in the world. India grows about 60 types of spices under varying agro-climatic conditions and soil types. India produces about 60 lakh MT of spices, of which, about 6.9 lakh MT (11%) is exported to more than 150 countries. The world demand for organic spices is growing rapidly in developed countries like Europe, USA, Japan and Australia. The current estimated share of organic foods in these countries is approximately 1 to 1.5%. Worldwide, food trends are changing with a marked health orientation. Since organic foods are free from chemical contaminants, the demand for these products are steadily increasing.

Export of major spices

Spice	Value USD (%)	Value USD
Cumin	38.89	212542273
Red chilli	18.40	100577510
Pepper	16.26	88872567
Turmeric	7.96	43525565
Green cardamom	3.17	17327896

What is organic farming?

Organic farming is holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. Organic production systems are based on specific and precise standards of production which aim at achieving optimal agro-ecosystems which are socially, ecologically and economically sustainable. IFOAM defines “organic agriculture” as: “*a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition,* *innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved."*

The International Federation of Organic Agriculture Movements (IFOAM) has formulated four broad principles of organic farming, which are the basic roots for organic agriculture growth and development in a global context. They are:

1. ***Principle of health**:* Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being.
2. ***Principle of ecology**:* Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.
3. ***Principle of fairness**:* Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.
4. ***Principles of care**:* Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment. It should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering.

Status of organic spices production in Sikkim

In Sikkim, large cardamom, ginger and turmeric are major spices cultivated under organic conditions. Large cardamom is one the important cash crops grown in the sub-Himalayan state of Sikkim. It is also cultivated in Darjeeling district of West Bengal and some other North Eastern Hill states like Arunachal Pradesh, Nagaland, Mizoram, Manipur, Meghalaya, Assam and parts of Uttarakhand. Nepal and Bhutan are the other two Himalayan countries where large cardamom is cultivated. Sikkim is the largest producer of large cardamom (4112 t) and constitutes the major share of Indian and world market (Anonymous 2017). In Sikkim, during 2016-17 the total area under large cardamom was 17484 ha with production of 4112 tonnes and productivity of 235 kg ha^{-1} (Anonymous 2017). Sikkim contributes 88% of the annual production of India. Sikkim is also among the major producer of ginger contributing five per cent to the country's production. Though productivity of the ginger from the state has increased from 4.8 tonnes/ha into 2002-03 to 5.4 tonnes/ha in 2016-17, however, it has not kept pace with the all India average. Ginger is cultivated in 10030 ha in Sikkim with total production of 54,986 tonnes and productivity of 5.48 tha^{-1} (Anonymous 2017). Turmeric is a very important spice in India, which produces nearly the entire world's crop and consumes 80 per cent of it. India is by far the largest producer and exporter of turmeric in the world. Turmeric occupies about six per cent of the total area under spices and condiments in India. In India, turmeric is cultivated in 1,92,916 ha with production of 9,73,098 tonnes (Spices Board, Govt. of India, 2012-13). In Sikkim, it is cultivated in an area of 1950 ha with total production of 5683 tonnes and productivity of 2914 kg ha^{-1} (Anonymous 2017).

Organic production of large cardamom in Sikkim

Climatic requirement

Large cardamom is a shade loving plant (sciophyte) and lower altitudes of cooler zones (proximal to the snow-line) and higher reaches of the warmer zones are best suited for its growth. Large cardamom belts experience mean annual ambient temperature range of 6^oC (December-January) and 30^oC (June-July) accompanied by constant high relative humidity. Continuous rain during flowering is detrimental, as it hampers the foraging activity of pollinating bees, thus affecting the flowers and resulting in poor capsule setting and barren spikes. Plants remain dormant during severe winter and can withstand up to 2°C but frost and hailstorms are injurious to large cardamom.

Varieties

There are mainly six popular cultivars of large cardamom *viz*., Ramsey, Ramla, Sawney, Varlangey, Seremna and Dzongu Golsey. Several others include Chivey, Ramsey, Gardo Seto Ramnag, Madhusey, Seto Golsey, Slant Golsey, Red Sawney, Green Sawney and Mingney.

Selection of site

Large cardamom performs well under partial shade (50 %). *Alnus nepalensis* (*utis*) is the most common shade tree and *Alnus nepalensis* (Himalayan alder)-large cardamom is very good agro-forestry system for sustainable production in the region. The other species of shade trees are *Termalia myriocarpa* (panisāj), *Bucklandia* spp. (pipli), *Macaranga denticulata* (malato), *Edgeworthia gardneri* (argeli), *Viburnum erubescens* (asare), *Maesachisia* (bilaune), S*ymplocos* spp. (kharane), *Albizzia lebbeck* (siris), *Erythrina indica* (phaledo), *Eurjata panica* (jhingani), *Schima wallichi* (chilaune) *etc*.

Field preparation and planting

The land selected for planting is cleared of all the under growth, weeds *etc*. Old large cardamom plants, if any may also be removed. Pits of size 30 cm x 30 cm x 30 cm are prepared on contours at a spacing of 1.5 m x 1.5 m from the centre of the pits. Wider spacing of 1.8 m x 1.8 m is recommended for robust cultivars like Ramla, Ramsey, Sawney, Varlangey *etc*. While closer spacing of 1.45 m x 1.45 m is advised for non-robust cultivators like DzonguGolsey, Seremna *etc*. Pits are left open for weathering for a fortnight and then filled with topsoil mixed with cow dung compost/FYM @1-2 kg per pit. Pit making and filling operation should be completed in the third week of May before the onset of pre-monsoon showers. Planting is done in June-July when there is enough moisture in the soil. A mature tiller with 2-3 immature tillers/vegetative buds is used as planting unit. Quality planting materials are to be raised in the nurseries or to be collected from certified nurseries for better production. Suckers/seedlings are planted by scooping a little soil from the centre of the pits and planted up to collar zone. Deep planting should be avoided. Staking is needed to avoid lodging from heavy rain and wind and mulching is done at the plant base.

Organic nutrient management

Replenishment of nutrients is very essential for sustained good yield and to compensate the nutrient loss from the soil. Application of well-decomposed cattle manure/compost or organic products @5 kg/plant at least twice a year in April-May and August-September is beneficial. Vermicompost, having favourable impact on soil physical properties and good source of nutrients, particularly in the beds is gradually becoming a popular organic manure.

Mulching and soil management

If the land is not terraced the soil base may be made by cutting the top soil from the upper half and placed on the lower half followed by mulching. Mulching at the plant base with easily degradable organic materials is good for conserving both moisture and soil. Mulch is well-known to improve the soil physical condition and fertility. Dried organic matter, leaves, weeds *etc*. can be used as mulch.

Water management

Large cardamom plants cannot thrive well under water stress. In the first year of planting irrigation is required at least once in 10 days during the dry months of September to March for better growth thereafter. It is observed that plant growth and productivity is higher in plantations where irrigation is provided. Depending on the availability of water sources hose/sprinkler/flood irrigation through small channels is advised. Water harvesting pits made in between four plants of nearby rows during rainy season can to some extent support the water requirement of the crop in the dry season and is a cost-effective option.

Shade management

It is noticed that dense shade or less shade hinders optimum crop growth and production. About 50% shade is found ideal. The lopping of branches of the shade trees is very important and should be done before the onset of the monsoon during June-July. But simultaneously over-exposure to direct sunlight causes yellowing of leaves. Therefore, judicious shade management is very important for good growth, timely flowering and for better yield. However, presently in Sikkim and other areas there is an increasing trend planting large cardamom in terraces and open fields without any shade with varying response. This will be future area of interest for the researchers' *vis-à-vis* crop longevity.

Pollinators of large cardamom

The bumble bee, *Bombus breviceps* and *B. haemarrhoidalis* have been recorded as important pollinators of large cardamom in all the altitudes. These bumble bees are called locally as Bhomora (*Nepali*), Boom boom taka (*Bhutia*) and Tungboom (*Lepcha*). Flowering in large cardamom spikes will be completed within 60 days. It is observed that during the initial flowering period (about 20 days from the starting of flowering) in all the altitudes; frequency of visit of *B. breviceps*is more. Later on, in mid and peak flowering period (21-60 days) visit of *B. haemorrhoidalis* is predominant. Each spike bears 40 to 50 flowers and only 10 to 15 capsules set per spike. The flowers remain viable for about 14 hours after opening. Anthesis starts at 8.00 am and ends at 8.30 am on sunny days and from 9.15 to 9.30 am on cloudy and rainy days. The stigma remains receptive for 24 hours on rainy and cloudy days and is limited to 2 hours on sunny days from 1.00 to 3.00 pm only.

Harvesting and threshing

The indication of time of harvest is when the seeds of top most capsules turn brown. As soon as the said colour appears and to enhance maturity bearing tillers are cut at a height of 30-40 cm from ground and left for another 10-15 days for full maturity. The spikes are harvested by using special knives known as "cardamom-knife" (*Elaichichhuri*).

Yield, storage and post-harvest operations

Harvesting begins early in the lower altitudes, during August-September and is as late as November-December at higher altitudes. The average yields range from 100 to 400 kg/ha. The fruit is a tri-locular, many seeded capsule. The capsule wall is echinated having reddish-brown to dark-pinkish in colour. The seeds are di-angular, whitish when immature and become dark-greyish towards maturity. Usually the capsules which are formed at the basal portion are bigger and bolder than others.

Curing

The quality of large cardamom is governed by its external appearance, which is influenced by colour, uniformity of size, shape, consistency and texture, and flavour, which ascertains taste and odour, and is affected by composition of aromatic compounds. Appearance provides a visual perception of co-uniformity in size, shape, consistency. The essential oil contains the volatile principles such as 1:8 cineole (75-85%), a-bisabolene (3-6%), r-terpinene (4-8%), a-terpineol + a – terpinyl acetate (3-6%) also the B-myrcene, nerolidol, pinene, thujene etc., are known in traces. The harvested spikes are heaped and capsules separated and dried. The cured capsules are rubbed on wire mesh for cleaning and removal of calyx (tail).

The fresh capsules are fleshy with almost 85% moisture. Their keeping quality is poor and is highly perishable. They are cured or dried to about 10-13% moisture on dry weight basis to prolong its shelf life. Cardamom is cured (*i.e.*, dehydration of the fruits over low sustained heat) in a curing furnace, the heat invariably coming from burning of wood fuel. Traditionally, locally made furnace, the "*bhatti*", crude and primitive in operation, is a stone-mud structure, cheap to erect and moderately efficient where capsules are dried by direct heating. Considerable loss of quality characteristics is seen with the *bhatties*, yet, they are common place in the entire cardamom belt.

Organic production of turmeric in Sikkim

Climatic requirement

Turmeric can be grown in diverse climatic conditions from sea level to 1500 m amsl in a temperature range of 20-35^{o}C with annual rainfall of 1500 mm or more under rainfed or irrigated conditions.

Soils

Sandy or clay loam soil with a pH range of 4.5-7.5 with good organic matter status and irrigation facility is most suitable. Soils with water stagnation and alkalinity are not suitable for turmeric cultivation. Turmeric requires deep tilth and heavy manuring for high yields.

Varieties

A number of local cultivars are available in the country. Lakadang variety of turmeric is mostly grown in Meghalaya and this variety is popular for high curcumin content of at least six per cent. Dzongu local, Allepey, Sudharshana, Suroma, Roma and Lakadang are grown in Sikkim. The cultivars most suitable for Sikkim are Lakadang and Megha Turmeric-1.

Crop rotation and mixed cropping

Turmeric can be grown as an intercrop in arecanut plantations. It can also be raised as a mixed crop with chillies, colocasia, onion, brinjal and cereals like maize, ragi, *etc*. In order to control soil-borne diseases, turmeric crop should be rotated with cereals/legumes after 2-3 years. It is beneficial, if legume crops such as soybean, black gram and French bean *etc*. are rotated.

Field preparation

A buffer zone of 25-50 feet is to be left all around the conventional farm for organic turmeric production, depending upon the location of the farm. The produce from buffer zone shall not be treated as organic. Turmeric being an annual crop, the conversion period required will be 2-3 years as is normal for any crop, turmeric can be cultivated organically an as intercrop or mixed crop with other crops provided all the other crops are grown following organic methods. The site selected should have good drainage facilities.

Land should be prepared to fine tilth with four deep ploughings. In Sikkim, farmers start land preparation little early (February-March) immediately after the receipt of early monsoon showers. Beds of convenient size, 1 m wide x 15 cm high with 50 cm spacing between the beds are prepared. Ridges and furrows are prepared in irrigated land and the rhizomes are planted in shallow pits on top of the ridges. Spacing generally adopted is 45-60 cm between the ridges and 15-20 cm between the plants. Dolomite should be applied @2 t/ ha and mixed with soil to ameliorate the soil acidity. In high rainfall areas proper drainage channels should be provided in the inter-rows to drain off stagnant water.

Propagation

The seed rate varies according to the type of planting material, spacing and weight of rhizomes. Well-developed, healthy and disease-free rhizomes are to be selected for planting. The source of seed should be selected carefully. In the beginning seed material from high yielding local varieties may be used in the absence of organically produced seeds. Thereafter, only carefully preserved healthy seed rhizomes which are collected from organically cultivated farms should be used for planting. Both mother and finger rhizomes are used. Mother rhizomes are planted as such or split into two; each having at least one sound bud whereas, the fingers are cut into 4-5 cm long pieces. 2 to 2.5 tonnes seeds are used for planting one hectare area. Small pits are made with a hand hoe on the beds with a spacing of 25 cm x 30 cm.

Use of chemical fungicides for rhizome treatment is strictly prohibited in organic turmeric production. Slurry of *Trichoderma viride* @5 g kg^{-1} of seed is prepared and used for treating the seed materials to control the rot disease. *Acacia* gum may be mixed with the slurry as an adhesive. Before planting, the rhizomes are soaked in the slurry for 30 minutes and then air- dried under shade. Rhizome should be stirred 3-4 times to ensure uniform soaking. Along with *Trichoderma*, rhizome can be treated with bio-fertilizers (*Azospirillum*, *Azotobacter*). Seed rhizomes are placed in shallow pits and then covered with well-decomposed cattle manure or compost mixed with *Trichoderma*.

Organic nutrient management

Turmeric needs heavy manuring. Application of well-decomposed farmyard manure (FYM) or compost @15-20 t ha^{-1} along with 250 kg neem cake and 150 kg ha^{-1} rock phosphate or vermicompost @10 t ha^{-1} is recommended through broadcasting and ploughing at the time of land preparation or as basal dressing by spreading over the beds or into the pits at the time of planting. Integrated application of FYM 10 t ha^{-1} and vermicompost 5 tha^{-1} along with 250 kg neem cake and 150 kg rock phosphate ha^{-1} is the best option for sustainable turmeric production. Organic manure can also be applied along with bio-fertilizers like *Azospirillum* and *Bacillus* (phosphate solubilizing bacteria) for better nutrition to the crop.

Mulching

Mulching in turmeric with paddy straw or green leaves (*Alnus nepalensis*, *Schima wallichii*) or available weed biomass (*Artemisia vulgaris*, *Chromolaena odorata*) is necessary to enhance the germination of rhizomes and prevent soil erosion during heavy rains. This also adds organic matter to the soil and conserves moisture during the latter part of the cropping season. The crop has to be mulched immediately after planting with green leaves @ 12-15 t ha^{-1}. Mulching may be repeated @ 7.5 t ha^{-1} at 40 and 90 days after planting after weeding, manuring and earthing up. Cow dung slurry may be poured on the bed after each mulching to enhance microbial activity and nutrient availability. In Sikkim, leaves of *Schima wallichii* (*Chilaune*) is preferred among the farmers as mulching material.

Water management

Turmeric is generally grown as rain fed crop. However irrigation has to be given when soil becomes completely dry. In the case of irrigated crop, depending upon the weather and the soil conditions, about 15 to 23 irrigations are to be given in clayey soils and 40 irrigations in sandy loams. In water scarce areas, suitable water conservation techniques (rainwater harvesting) have to be adopted for providing protective irrigation. HDPE-lined water harvesting tank is beneficial during dry season. At harvest light irrigation is recommended two-three days for comfortable digging of the rhizomes.

Weed management

Weeding should be done thrice at 60, 90 and 120 days after planting depending upon the weed intensity. Earthing up should be done after 60 days. Mulching reduces the weed problem.

Harvesting

Time of harvest depends upon the variety and usually extends from January to March. The crops become ready for harvest in 9-11 months after planting. During harvest whole plants are removed without damaging the rhizomes. The rhizomes are harvested by ploughing the land and gathering by hand-picking or the clumps are carefully lifted with a spade. The harvested rhizomes are washed thoroughly to remove soil and other extraneous matter adhering to the rhizomes. Fingers are separated and mother rhizomes are used for seed purposes. The green turmeric or fingers are cured for obtaining dry turmeric.

Yield

A good crop of turmeric may give yield about 20-25 t ha^{-1} under organic conditions.

Storage and processing

Curing

Fresh turmeric is cured for obtaining dry turmeric. Curing involves boiling of rhizomes in fresh water to soften them and remove the raw odour. The cured rhizomes are dried under the sun. The optimum stage of the curing can be judged by the softness of cured rhizomes or by piercing with a blunt piece of wood. The stage at which boiling is stopped largely influences the colour and aroma of the final product. Over-cooking spoils the colour of the final product and under-cooking renders the dried product brittle. The cooked turmeric is taken out of the pan by lifting the troughs and draining the water into the pan itself. They are then drained and dried in the sun for 10-15 days in an electric drier until they become dry and hard. These rhizomes are then ground to obtain turmeric powder. The dry recovery varies from 15 to 25%. The processing of turmeric is to be done 2 to 3 days after harvest. Turmeric can also be processed after storing under shade or covered with sawdust or coir dust in case of any delay in processing.

Drying

The cooked fingers/mother rhizomes are spread on bamboo mats or cement floor under the sun for drying 10-15 days for complete drying. The rhizomes are spread in 5-7 cm thick layers for desirable colour of the dried product. During the night time, the rhizomes are heaped or covered with material which provides aeration. Turmeric can be dried by putting the cured rhizomes in cross-flow hot air at a maximum temperature of 60^{o}C. In case of sliced turmeric, artificial drying has clear advantage in giving a brighter coloured product than sun drying which tends to undergo surface bleaching. The yield of the dry product varies from 10-30 per cent depending upon the variety and the location where the crop is grown.

Export potential

There is excellent potential for exporting organic turmeric. The countries like Germany, France, Netherlands, UK *etc.* in Europe, USA in North America and Japan in the Far East region import sizeable quantity (approx 11,682 tons) of turmeric from India. There is a good potential for exporting 500 to 1000 tons of organic turmeric to all the above mentioned countries in future. However, for promoting further exports, quality standards of powdered turmeric of European Spice Association need to be adopted and maintained. Indian spices have been able to record strong export gains over the past five years, registering a compound annual growth rate in value of 14% in rupee terms and 5% in US dollar terms – even though the quantities exported have not shown commensurate increase.

Packaging

(a) **For exports:** Packaging is normally done in clean gunny bags and it should be polythene laminated gunny bags.
(b) **For domestic markets:** For domestic markets, turmeric is packed in gunny bags and jute sacks.

Turmeric grown in southern states like Kerala, Tamil Nadu, Karnataka and Andhra Pradesh find major markets in states like Maharashtra, M.P, U.P, and further goes to Delhi, Punjab and Haryana. Turmeric grown in Gujarat is distributed in nearby markets of Rajasthan. Turmeric from Orissa and West Bengal find markets in Chhattisgarh, Jharkhand and Bihar *etc*. Turmeric from Sikkim is distributed in North Eastern states.

Organic production of ginger in Sikkim

Climatic requirements

Ginger is a tropical plant and requires warm humid climate for its cultivation. Well distributed rain during growing season *i.e*., from April to October is ideal for its cultivation. This is the reason that this crop is grown from 300-1500m amsl in Sikkim, where the temperature remains higher during the growing period. Well distributed rainfall during growing season and dry season during the land preparation as well as before harvesting is required for good growth and yield of the crop. Dry weather with average temperature range of 28-30°C for about a month before harvesting produces good yield of ginger. High humidity throughout the crop period is necessary.

Soils

Ginger is grown on terraces structured on hill slopes in Sikkim. Ideal soil for ginger cultivation is good garden soil, rich in humus, light, loose, friable, with good drainage and aeration with at least 30 cm depth. It grows well in sandy loam soils with pH of 6-7.5 however, rhizome growth is better on slightly acidic soil. Preparation of land starts with the receipt of early rain. Generally 2-3 ploughing is recommended or the land is dug 2-3 times to obtain a fine tilth before sowing. Raised beds (15-20 cm height) having 75-100 cm in width are used for sowing. Raised beds with a gentle outward slope avoid water-logging in the ginger field.

Cultivars

The important local cultivars grown in the state are Bhaise, Gorubathane and Majhauley.

Seed rate and sowing

Ginger is propagated by portions of the rhizome known as seed rhizomes. Carefully preserved seed rhizomes selected from the previous season through morphological diseases and insect pest-free appearance are cut into small pieces of 2.5-5 cm length weighing 40-50 g each having one or two good buds are suitable for planting. The seed rate varies from region to region and with the method of cultivation adopted. In Sikkim, seed rate is very high because farmers use the seed rhizomes of around 150 g. At higher altitudes the seed rate may vary from 2000 to 2500 kg ha^{-1}.

Sowing starts from last week of February to early-March and continues till April. Ginger seed rhizomes are line sown in shallow rows on raised beds with a hand hoe and covered with thin layer of soil and levelled. Before sowing the seed rhizomes should be treated with 47°C hot water, biocontrol agents (*Trichoderma viride* @2%) for 30 min., drained and then planted at spacing of

30-45 cm between rows and 15-20 cm between plants. Depending on the width of the beds, ginger is sown in 2-4 lines. When the crop is intercropped with maize the planting distance between rows is maintained at 60-90 cm and maize is sown in between the rows of ginger.

Organic nutrient management

At the time of planting, well-decomposed farmyard manure or compost @ 20-25 t ha^{-1}, neem cake @2 t ha^{-1}, biofertilizer (*Azospirillum* + PSB) @5-6 kg ha^{-1} applied in rows at the time of planting helps in reduction of incidence of rhizome rot and increases the yield. Two months after planting, vermicompost @5 t ha^{-1} should also be applied for better growth and production. Since edible part of ginger is rhizome, prior to planting of the seed rhizome in the soil, six-inch cushion of leaves increases the production of ginger by the loosening of soil texture around seed rhizome at later stages.

Mulching

During rainy season, weeds are major problems of the North-East. Mulching is essential to reduce the weed problem. Mostly, leaves are used for the mulching of ginger crop. Since, most of the deciduous plants shed their leaves in winter season, it is, therefore, better to collect shed leaves for the mulch of ginger at the time of sowing. The best mulching material in Sikkim is *Schima wallichi* (*Chilaune*) followed by *Artemisia vulgaris* (*Titepati*) which minimize some disease problems also. The first mulching is done at the time of planting with dried leaves. Mulching is to be repeated at 40^{th} day and 90^{th} day after planting, immediately after weeding and application of manure.

Irrigation and drainage

Irrigation is not necessary under Sikkim conditions as soil has enough moisture due to regular rain but drainage is absolutely necessary for the prevention of disease incidence like wilt and soft rot due to water logging. Sufficient soil moisture should be present in the soil during sprouting, rhizome initiation and rhizome development.

Crop rotation and mixed cropping

Ginger should be commonly rotated with crops like tapioca, chillies and rice in rain fed areas and leguminous crops, maize and vegetables in irrigated conditions. Rotation of the field for ginger production should be strictly followed to avoid insect pest and disease problems. Ginger cultivation can be taken up in the same field after a gap of 3 years.

Cultivation practices

Weeding is done just before manure application and mulching. Two to three weedings are required depending on the intensity of weed growth. Proper drainage channels are to be provided to drain off excess and stagnant water. During hoeing, care should be taken to prevent disturbance to the rhizomes that may cause injury or exposure.

Harvesting

Ginger as fresh crop should be harvested before attaining full maturity means when rhizomes are still tender, low in pungency and fibre content, usually from fifth month onwards after planting. Harvesting for the preserved ginger should be done after 5-7 months of planting while harvest for dried spices and oil is best at full maturity *i.e.*, between 8-9 months after planting when the leaves start yellowing. Rhizomes to be used for planting material should be harvested until the leaves become completely dry. After digging, rhizomes should be dried in shade and stored in pits covered with 20 cm layer of sand alternating every 30 cm layer of rhizomes. These pits should be dug under a thatched roof to protect the rhizomes from rain, water and direct sun.

Yield

Average yield varies from 12-15 tonnes per hectare. However, recovery of dry ginger varies from 20-22%. Presently, the average productivity in the state is only 4.96 t ha^{-1} which provides ample opportunities to more than double the production in view of the yield potential.

Storage

Farmers store ginger rhizomes in their houses either on floor or racks made of bamboo while some keep in pits and cover with rice straw-dry leaves and soil. The bottom of the pit is lined with sand and rice straw and a roof is provided over the pits. Normally healthy and bold rhizomes are selected for storage and frequently diseased rhizomes are sorted out to avoid spread of diseases.

Washing and drying

After harvest, the fibrous roots attached to the rhizome should be trimmed off and soil removed by washing. Rhizomes should be soaked in water overnight and then cleaned. Peeling or scraping reduces drying time, thus minimizes mold growth and fermentation. However, scraping process tends to remove some of the oils constituents which are more concentrated in the peel. By removing the external corky skin the fiber content also decreases. After scraping, the rhizomes should be sun dried for a week with frequent turning and well-rubbed by hand to remove the outer skin. This is called as the unbleached ginger. The peeled rhizomes should be repeatedly immersed in 2% lime solution for 6 hours and allowed to dry in the sun for 10 days while the rhizome receive a uniform coating of lime and moisture content should be around 8-10%. This is called as bleached ginger which has improved appearance with light bright colour.

Processing

Ginger is an extremely versatile commodity. It can be processed to medical and sweet products. Ginger is processed to give ginger oil, oleoresins, candy, preserves, and ginger powder, starch from sport ginger, ginger brandy wine, beer, medicinal beverages and pastes. Some of the ginger products are drained ginger, syrup ginger, dusted ginger, crystallized ginger, brined ginger, pickled ginger, and dried ginger *etc*. Ginger can be used in a myriad of food product ranging from bakery items to confectionary, beverages, marinades and sources, candies, ice cream and desserts, jams and spreads, prepared foods, health foils and nutraceuticals.

Marketing and trade

There is a ready market for fresh ginger in Sikkim. Before bringing the ginger to the market farmers clean the ginger after harvest by removing adhering soil particles. Sorting is done at traders' level to remove light, diseased, cut or deformed ginger rhizomes. In this process 8-10 per cent produce is discarded. About 30% produce is sold in the village itself to the local merchants or commission agents. The remaining produce is taken to the market for sale to commission agents/wholesalers. The main marketing centres in Sikkim are Gangtok, Pakyong, Singtam and Rangpo in the East district; Namchi, Jorethang and Melli in South district; Mangan and Dikchu in North district and Gyalshing, Reshi, Legship and Nayabazar in the West district.

The quantum of ginger going out of the state ranges from 16,422 tonnes (1998) to 17,600 tonnes (2000-01). About 30-40% of the produce is retained as seed. The important markets dealing with ginger in the state are Naya Bazar, Reshi (30%), Singtam (25%), Jorethang, Namchi (20%), Melli (15%), Pakyong (3%), Rangpo (3%), and others (4%). Delhi market is the major consumer of Sikkim ginger (70%) followed by Punjab (10%), Uttar Pradesh (10%), West Bengal (5%) and others (5%). Most of the ginger reaching Delhi is further traded with markets in other states.

The largest exporters in the world are Thailand, China, India, Brazil and Indonesia. The biggest importers of ginger are Japan 91,685 tonnes (1999) followed by USA (15,583 tonnes), Netherlands (4,729 tonnes), Canada (4,606 tonnes), Singapore (3,969 tonnes) and others.

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ORAL PRESENTATIONS

OP16

Eco-friendly and alternative weed management practices in ginger (*Zingiber officinale* Rosc.) in Darjeeling Himalayas

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A field experiment was conducted during 2016 and 2017 to evaluate the growth and yield of ginger as influenced by eco-friendly and alternative weed management practices. The treatments consisted of dry weed biomass mulch @ 5.0 t/ha (T1), paddy straw mulch @ 5.0 t/ha (T2), FYM mulch @ 5.0 t/ha (T3), dry leaves of *Schima wallichi* @ 5.0 t/ha (T4), dry leaves of *Artimesia* sp. and *Eupatorium* sp. @ 5.0 t/ha (T5), hand weeding (twice) at 55 and 70 DAS (T6) and unweeded control (T7). The results indicated that, hand weeding twice at 55 & 70 DAS appreciably reduced the total weed population and total dry weight of weeds than unweeded control plot at all the stages of crop growth. However the highest plant height (81.01 cm), number of leaves per clump (65.94), number of pseudostem per clump (5.05), yield per plant (0.260 kg) and yield per ha (54.12 t) were recorded under hand weeding twice at 55 and 70 DAS compared to control. The results showed that, it is necessary to cover the soil surface with different mulch materials and manual weed control practices to achieve control of weeds along with enhanced yield attributes and thereby the yield.

OP17

Volatile oil contents as affected by PGPRs and other organic inputs in commercial ginger varieties of Sikkim

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Rhizomes of two commercial varieties of ginger *i.e.*, Bhaise and Majauley were treated with different organic inputs including PGPRs alone and in combinations with 43 treatments. After harvest, the volatile oil content was assessed using Socsplus- SCS 06 DLS oil extractor. The volatile oil content ranged from 1 to 7.2%. In general, the volatile oil content in Bhaise was higher as compared to Majauley. It was found that PGPRs and organic inputs play a vital role in improving the volatile oil content in ginger.

OP18

Technologies for organic production of turmeric

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Organic products are grown without the use of chemical fertilizers and pesticides with an environmentally and socially responsible approach.Turmeric can be cultivated as an intercrop along with other crops provided that all the companion crops are also organically grown. Turmeric is grown in rotation with many agricultural and horticultural crops. A buffer zone of 25 to 50 feet shall be maintained if the neighbouring farms are non-organic. The produce from this zone shall not be treated as organic. Turmeric requires a conversion period of two years. In the case of irrigated crop, ridges and furrows are prepared and the rhizomes are planted in shallow pits on the ridges with normal spacing. Solarization of beds is a pre-requisite in checking the multiplication of pests and disease causing organisms. High yielding local varieties may be used for planting in the absence of organically produced seeds. While planting, the seed rhizomes shall be placed in shallow pits filled with compost enriched with *Trichoderma*. Mulching the beds with green leaves is an important practice. Application of well rotten cow dung or compost @2-3 tonnes /acre may be applied as basal dose while planting. In addition, application of neem cake @ 0.8 tonnes/ acre is also desirable.

SESSION III:

NUTRIENT, SOIL, WATER AND PLANT HEALTH MANAGEMENT

CLIMATE RESILIENCE IN SPICE CROPS PRODUCTION AND MITIGATING CLIMATE CHANGE

TECHNOLOGY-LED ORGANIC PRODUCTION OF SPICES AND SAFE FOODS

POSTER PRESENTATIONS

PP24

Calcium chloride enhances drought tolerance traits in black pepper

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Drought is the most important factor limiting the black pepper productivity in India. As the frequency of occurrence of drought is increasing due to climate change, innovative, low cost technologies are needed to ensure survival of black pepper and sustain its productivity under drought. Though our previous results showed that abscisic acid could be a good option to induce drought tolerance, due to high cost of ABA, we attempted to evaluate the impact of the low cost chemical, $CaCl_2$ on drought tolerance in the present study. The stomatal behavior, membrane leakage, relative water content and two important reactive oxygen species (H_2O_2 and SOD) were studied in four black pepper genotypes using desiccation control and $CaCl_2$ sprayed black pepper plants. The results revealed that, the $CaCl_2$ sprayed plants showed reduced membrane leakage and increased relative water content when compared to desiccation control. The significant reduction in stomatal pore size, reduced hydrogen peroxide levels and increased SOD activities indicated the positive influence of $CaCl_2$ spray in mitigating drought in black pepper. As this study was conducted under controlled condition, this needs further field validation to recommend $CaCl_2$ spray for drought mitigation in black pepper.

PP25

Delineation of efficient black pepper zones in North East and South India

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Black pepper (*Piper nigrum* L.) popularly known as "King of Spices" and "Black Gold" is native to Western Ghat region of India. The crop is adapted to humid tropical and subtropical climate. At present more than 25 countries cultivate this crop in the world. Historically, India was a leader in area and production, but now, India is not the top producer. Important black pepper producing states in India, are Kerala, Karnataka, Tamil Nadu, Assam, Meghalaya, Goa and Nagaland. It is cultivated to a lesser extent in Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Gujarat, Maharashtra, Odhisa, Puducherry, Telangana, Tripura, West Bengal, as the area and production is less, it is not reflected in the government estimates. In this study we have attempted to delineate efficient black pepper producing zones based on the relative spread and yield index. The district level area and production statistics of black pepper was collected from Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Government of India, New Delhi or from respective State Department. Mean Relative Spread Index (RSI) and Relative Yield Index (RYI) were calculated and efficient zones were identified. Out of 97 black pepper growing districts in India, 84 were delineated as efficient producing zones with twenty six districts in Assam, 2 districts in Goa, 19 districts in Karnataka, 9 districts in Kerala, 10 districts in Meghalaya, 7 districts in Nagaland and 11 districts in Tamil Nadu.

PP26

Management of virus affected black pepper plantations through soil and plant health maintenance

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Black pepper is a crop of commercial importance and its productivity declines due to various biotic and abiotic factors among which, stunt disease caused by CMV and PYMoV is one of the serious and emerging constraint. The disease severity is aggravated in poorly nourished plantations and yield loss varies from negligible to 85%. In India, the disease is prevalent in Wayanad and Idukki districts, Kerala and Kodagu and Hassan districts, Karnataka. Field trials were conducted in farmer's field at various locations in Karnataka consecutively for three years, where individual vines were graded as mild and moderately affected based on visual symptoms. The treatments composed of combinations of FYM, NPK, foliar micronutrient (IISR Black pepper special) and PGPR. The combined application of manure, nutrients and PGPR boosted the health of both mild and moderately virus infected vines significantly. Combined application resulted in more number of leaves, well developed canopy and spike intensity per unit area and fresh yield (30-50% higher) in virus infected vines as compared to control. The health status of the vines also scored high, 2.9-3.2 (on the scale of 1-5 from severely infected to very healthy based on visual scoring) under both categories showing improved health of the vines, thus masking the symptoms. The fresh yield was significantly higher with FYM + NPK + PGPR + micronutrients (3.6-7.1 kg/vine) application compared to control (2.4-4.4 kg/vine) across locations. The integrated package developed is recommended for reviving and sustaining health and yield of mild/ moderately categories of vines in plantations.

PP27

Occurrence and symptomatology of Giant African Snail *Lissachatina fulica* (Bowdich) on ginger and black pepper in Kodagu

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Apart from various biotic factors affecting the production of spice crops, the giant African snail *Lissachatina fulica* has been observed causing severe damage on ginger and black pepper. Though it was reported earlier feeding on spices, the severe damage on ginger was noticed for the first time in Shanivarasanthe, Kodagu (N 12°25.112' E 075°44.676'). The eggs were creamy yellow, measured about 5.19 ± 0.09 mm in length and 4.16 ± 0.11mm in width. Five different stages of snails were collected and measured, the average length and width of the shells were 125.4 & 55.9 mm, 99 & 43.2 mm, 67.7 & 32.07 mm, 48.1 & 24.9 mm, 10.1 & 6.4 mm, respectively. All the stages weighed in a range between 6.67 to 76 g. The shell was light coffee brown, narrow to conical with 7-9 whorls (in matured adult) with weak yellowish vertical markings. Extensive damage is done by feeding on young as well as emerging shoots of ginger. On an average, 2-3 snails aggressively feed at the base

of the clumps and suppress the growth of young shoots. The snails hold the plant parts firmly and slowly grind the tissues using *radula*. It damages black pepper leaves, vines, clinging roots especially at nodal region. It completely defoliates the lamina and leaves only midrib. The affected nodes become dry and were left only with fibrous material. The damage severely affects the establishment of new pepper plantation and also the standard trees such as *Erythrina* and oak.

PP28

Pythium deliense- a pathogen associated with the rhizosphere of yellowing and wilt affected black pepper vines

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During the course of an investigation on isolation of *Phytophthora* from the rhizosphere of wilt affected black pepper, *Pythium* species was frequently encountered in almost all soil baiting assays. *Pythium* sp. was isolated from the baits and pathogenicity assays were perfomed on eight black pepper varieties *viz*., Subhakara, Sreekara, IISR Girimunda, Pournami, Panchami, IISR Malabar Excel, IISR Thevam and IISR Shakthi. The leaf and stem infection could be noticed in all the varieties within 24 hours but the root infection was noticed after 9 days of inoculation thereby proving the Koch's postulates. Microscopic morphology revealed simple filamentous inflated /torulated sporangia, with smooth oogonia, highly aplerotic oospores, broad apical intercalary antheridia and bending of oogonial stalks towards the antheridia characteristic to *Pythium deliense.* ITS rDNA amplification using universal primers ITS 1 and 4, showed a product size of 700 bp which on sequencing and NCBI blast search analysis showed 99% identity to *P. deliense*. It is confirmed from the present study that *P. deliense* is also associated with black pepper in causing vine death symptoms during post monsoon season. The isolates of *P. deliense* grows at a pH range of 4.5-10.0 and a temperature range of 15-40^{o}C. Among the fungicides evaluated, RIL (400 ppm), metalaxyl-mancozeb (0.125%) and propiconazole (0.2%) were found highly inhibitory when compared with copper oxychloride. *In vitro* evaluation of potential bioagents showed that the pathogen is highly sensitive to *Trichoderma harzianum* and five potential *Streptomyces* strains *viz*., IISR Act 1, Act 2, Act 25, Act5, Act9. The present study constitutes the first report on the association of *P. deliense* from the rhizosphere of black pepper from India in association with wilting.

PP29

Rehabilitating black pepper cultivation for sustainability in Kozhikode District, Kerala

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Kerala is the leading producer of black pepper in India with Idukki and Wayanad as the two major producing districts with an area of 42920 and 9527 ha, respectively. North Kerala districts *viz*. Kozhikode, Malappuram, Kannur and Kasaragod comprise 13650 ha under black pepper with a production of 5127 MT and productivity of 375 kg/ha in 2013-14. The average productivity of black pepper is 600 kg/ha in Karnataka and 470 kg/ha in Kerala. There is enough potential to increase the productivity by reducing the yield gap through scientific management of the crop. Studies in major pepper growing areas of Kerala showed that poor soil fertility (high acidity, low K, Ca, Mg and B and high P in soils), low adoption of improved varieties and its scarcity, low adoption of scientific management practices and biocontrol agents are major constraints. Field level demonstrations (FLDs) were conducted at 24 farmer's field in three panchayats (Thamaraserry, Koorachund and Chakkittappara) of Kozhikode district with improved varieties of black pepper and 20 farmers' participative nurseries wherein the farmers were trained on nursery and field management. Six FLDs on site specific nutrient management were conducted in the panchayats to demonstrate the benefits of balanced nutrition. Each farmer could produce 500-950 rooted cuttings and many have sold the extra cuttings to other neighbouring farmers after meeting their own requirement. Significantly higher spike intensity and yield increase was observed in site specific soil nutrient (SSN) application and soil application + foliar spray of micronutrient (SSN + FS) as compared to farmers practice (FP). The yield (kg/standard) increase was 46.1% and 80.8% higher in SSN and SSN + FS as compared to FP.

PP30

Site specific fertility management for productivity enhancement of black pepper and nutmeg

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The objective was to fine tune the best management practices (BMP) from soil and plant analysis data and demonstrate the productivity enhancement of spices (black pepper and nutmeg) under mixed farming systems in farmer's fields. Experiments to optimize external inputs were conducted for nutmeg in Agro Ecological Unit (AEU) 9 (Mookannur Panchayat, Ernakulam district, Kerala) and for pepper in AEU 11 (Naduvannur and Arikulam Panchayats, Kozhikode district, Kerala) of Kerala State. The initial samples from the base and inter space of black pepper vines and nutmeg trees showed that the soils are highly acidic with medium to low organic carbon and therefore restricted N supply. Available K and B were also low. The P availability was high and the available Al was also found to be high in black pepper, whereas, the available P was very high in nutmeg basins with traces of Al. Based on these findings, the nutrient management strategy was worked out with lime and gypsum combinations and site specific major nutrient doses and crop specific micronutrient foliar sprays.

Significant increase in soil available P, K, Ca, Mg, Zn and Cu was observed in BMP adopted plots as compared to farmers practice. Also the surface soil recorded significantly higher available nutrient status as compared to deeper layers. The systematic management practices like removing branches of thread blight disease affected nutmeg trees and spraying with Bordeaux mixture (1%) with the onset of monsoon, helped to reduce the incidence of blight disease in the experimental plots. The results showed that application of soil amendments for correcting pH, site specific fertilizers and foliar micronutrient supplementation has helped in increasing the black pepper yield by 76.0-97.0% over control (farmers practice). Similarly in nutmeg, application of amendments along with site specific nutrients and micronutrients has increased the yield significantly (up to 50%) over the farmers practice. The farmers have registered an increase in income of Rs. 30,000-40,000 by the adoption of BMP in homestead cultivation of nutmeg in one year.

PP31

Streptomyces spp. from black pepper rhizosphere: potential biological source for novel antimicrobial compounds

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The present study was undertaken to assess the effect of culture filtrates and secondary metabolites of three *Streptomyces* spp. from black pepper rhizosphere with biocontrol and growth promoting traits against *Phytophthora capsici* and *Sclerotium rolfsii*. The isolates *viz*., IISRBPAct1, IISRBPAct25 and IISRBPAct42, suppressed the growth of *P. capsici* and *S. rolfsii* under *in planta* conditions*.* Crude culture filtrate of IISRBPAct1 and IISRBPAct25 were inhibitory to mycelial growth of *P. capsici* and sporangial formation. Crude culture filtrate of IISRBPAct1 completely inhibited the zoospore germination while IISRBPAct25 reduced germination rate to 95.6%. Similarly, mycelial growth of *S. rolfsii* was inhibited to >50% by IISRBPAct1 and IISRBPAct25, while IISRBPAct42 showed only 26.90% inhibition. IISRBPAct1 and IISRBPAct25 were highly inhibitory to sclerotium formation even at 1% concentration. The secondary metabolites of three isolates were extracted in three solvent systems and ethyl acetate extract of IISRBPAct1 showed highest activity towards *P. capsici* (73.5% inhibition) while the butanol extracts of IISRBPAct25 showed highest activity against *S. rolfsii* (74.7% inhibition). The active chemical moiety present in these extracts was analyzed and a total of 51 compounds were identified from ethyl acetate extract of IISRBPAct1 and 11 compounds from butanol extracts of IISRBPAct25. Among the compounds detected brevianamide F, enniatin B, harzianopyridone 1, harzianopyridone 2, isonitrinic acid E, natamycin, trichodermin, and zeaenol are found as major antifungal metabolites and harzianolide is found as a plant growth promoting agent. Among the identified compounds, (2E, 6E)-farnesol, (2R)-2, 3-dihydroxypropyl palmitate, dihydrocoriandrin, Gamma-CEHC, N-[(2S, 3R, 4E)-1, 3-dihydroxy-4-octadecen-2-yl]acetamide, salfredin B11, levetiracetam and tetradecenoylcarnitine are the first report of its kind from *Streptomyces* sp. The present study emphasizes the biological significance of black pepper rhizosphere *Streptomyces* spp. for the biological source for new anti microbial compounds.

PP32

Empirical evidences on the ecological nexus of the tropical cardamom production system

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The human dependence and dominance on the world's tropical forests has been increasing and it will continue to increase in the future mainly for food, water, energy and timber. Long term land use change in tropical forest particularly to perennial spice plantation agro-forestry can have considerable negative feed backs on its local climate system. The local impact of tropical forestland use not only affects its hydrological cycle but also local soil and climatic elements. The ongoing high

density and intensive cardamom farming practiced for decades in Indian cardamom hills will also go on because of nonavailability of suitable forest lands for expansion and realization of continuous higher yields. As of now, most environmental compartments in Indian cardamom hills are studied as independent systems and thus many aspects are overlooked while making recommendations on soil and forest canopy work. Therefore, misconceptions and speculations still exist around the linkages between climate, cardamom and forest. Studying and re-understanding the present climate-cardamom-forest nexus is essential for sustainable cardamom production as well as the well being of Indian cardamom hills. For that reason, we intend to explain the critical components based on observed values why and how the climate-cardamom-forest nexus is so important with respect to environmental protection and sustainable cardamom productivity. The empirical analysis finally proposes future research areas besides new hypotheses.

PP33

Identification and characterization of *Neopestalotiopsis clavispora* associated with leaf blight of small cardamom (*Elettaria cardamomum* Maton)

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Leaf blight, a major foliar disease prevalent in all cardamom cultivating tracts manifest in diverse forms of symptoms. In the present study, six symptomatological variants were delineated based on foliar symptoms in cardamom genotypes (Malabar, Mysore and Vazhukka) and designated as SV 1 to SV 6. Among the symptomatological variants, SV 1, SV 2, SV 3 and SV 6 were more pronounced in Vazhukka while, SV 4 and SV 5 were prominent in Malabar genotype. Subsequent isolation from the variants yielded whitish colonies, which were correspondingly coded as SV 1 to SV 6. The conidia were fusiform, 5-celled, with three median versicoloured cells, two terminal hyaline cells and measured 23.1 - 27.25 × 3.84 - 4.43 µm. The apical cells had 2 to 3 tubular, flexuous, unbranched appendages whereas, the basal appendage was single, tubular and unbranched. Conidial characteristics and molecular characterization with internal transcribed spacer rDNA region, partial β-tubulin, translation elongation factor 1 alpha and large subunit (28S) of the nrRNA genes revealed identity of the pathogen as *Neopestalotiopsis clavispora*. The pathogenicity test was performed on Malabar, Mysore and Vazhukka genotypes and Koch's postulates were proved. *In vitro* interaction at three temperature regimes indicated that, *N. clavispora* was inhibitory to *Colletotrichum gloeosporioides* at 10°C and 30°C. Among the fungicides, carbendazim, propiconazole and carbendazim-mancozeb completely arrested hyphal growth of *N. clavispora* under *in vitro* conditions. The present study constitutes first report on the association of *Neopestalotiopsis clavispora* with leaf blight disease of small cardamom.

PP34

Isolation, characterization and evaluation of fungal endophytes against major diseases of small cardamom

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Small cardamom (*Elettaria cardamomum*) popularly known as queen of spices and laurels of Western Ghats is challenged by several biotic and abiotic stresses. Rhizome rot (*Rhizoctonia solani*, *Pythium vexans* and *Fusarium oxysporum*) and leaf blight (*Colletotrichum gloeosporioides*) are major diseases and cosmopolitan in distribution. Endophytic fungi were isolated from leaves, petiole, stems, root and rhizomes of cardamom varieties and allied genera. A total of 109 fungal endophytes were isolated and evaluated against the pathogens. Four endophytic fungi *viz*., AsuPe 1 (*A. subulatum* isolate) against *C. gloeosporioides*, AgR 5A (*Alpinia galanga* isolate) against *R. solani*, Cb 2 (isolate from the variety Appangala 1) against *P. vexans* and AgR5d (isolate from *Alpinia galanga*) against *F. oxysporum* were shortlisted for further evaluation under pot culture experiments. The variety Appangala 1 was used in pot culture experiment and all the isolates tested showed positive results in curtailing the pathogens. For mass multiplication, locally available material was tested and coffee husk 50% + FYM 50% showed higher cfu/ml after thirty days post inoculation. The isolate AgR 5A, Cb2 and AgR 5d were found compatible with metalaxyl - mancozeb (0.1%) and Asu Pe1 was compatible with carbendazim. Sequencing of ITS region revealed that, AgR 5a (MG651866) and AgR 5d (MG651867) belonged to *Tulasnella* sp. and Cb2 (MG650119) and AsuPe1 (MG650121) belonged to *Phoma* and *Chaetomium* species, respectively. Further, the activity of peroxidase (PO) and polyphenol oxidase (PPO) tested with native PAGE showed higher activity of both the defense enzymes in endophytes treated plants.

PP35

Studies on insect pests of large cardamom (*Amomum subulatum* Roxb.) in Darjeeling Himalaya of West Bengal

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Large cardamom (*Amomum subulatum* Roxb.) representing the family Zingiberaceae is one of the major golden cash crop grown between elevation of 600 and 2000 m in tropical wet evergreen forest of Eastern Himalaya in India (Sikkim and Darjeeling areas), Nepal and Bhutan. With the ever changing climatic scenario, the status of many insect pests has also been changed like major insect pest become minor or secondary and minor become major. During July 2014 to July 2017 in newly planted plantation, studies were conducted on insect pests of large cardamom at Pedong, Kalimpong, Darjeeling, West Bengal (Latitude 27° 9' 31'' N, Longitude 88° 37' 16'' E and Altitude 1200 m MSL). The study revealed the incidence and faunastic composition of sixteen species of insect pests of large cardamom. They belong to six insect orders *viz*. Lepidoptera (five species), Coleoptera (four species), Hemiptera (four species) and one each species from Diptera,

Thysanoptera and Orthophtera. Among them, stem borer, *Glyphepterix* sp. (Lepidoptera: Glyphiperidae), shoot fly, *Merochlorops dimorphus* (Diptera: Chloropidae), leaf caterpillar, *Artona chorista* (Lepidoptera: Zygaenidae) and white grub, *Holotrichia* sp. (Coleoptera: Melonthidae) caused substantial damage to large cardamom. Few clumps of large cardamom had *Foorey* or virus yellow disease symptoms, which is known as aphid vector transmitted disease. At Pedong, one species of predatory Pentatomid bug was recorded on leaf caterpillar with the ability to kill 1-3 larvae/day by sucking body fluid.

PP36

Effect of herbicides on growth and yield in ginger (*Zingiber officinale*)

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Ginger (*Zingiber officinale* Rosc.) is an important major spice belongs to the family Zingiberaceae valued for it aroma, flavor and also for it's medicinal properties. Ginger has. As the crop is slow germinating, slow initial growth rate, shallow root system weed competition is expected to be tremendous. In spite of the divers and highly competitive weed flora existing in the ginger growing areas of tribal area of Visakhapatnam, weeds cause huge reduction in crop yield and increases the cost of cultivation in crop production. In this point of view, a field experiment was carried out during 2016-17 in randomized block design with three replications under AICRP on Spices at Horticultural Research Station, Chintapalli, Dr. YSR Horticultural University, Andhra Pradesh with twelve treatments. Observations revealed that, maximum plant height recorded in the treatment T12 (Weed free check with regular Hand weeding) (45.75 cm) followed by T9 (application of Oxyflurofen as Pre-emergent @ 23.5% EC, 0.3 kg a.i./ha followed by Quazilofop ethyl as post emergence at 30 days of crop @ 5% EC, 0.05 kg a.i./ha followed by by hand weeding at 90 days of crop) (44.72 cm), which are on par with each other. T9 and T12 are on par with each other in terms of number of tillers, yield per plant yield per plot. Un weeded control plot recorded lowest plant height and number of tillers as weeds like cypress, cynodan, *Phyllanthus niruri, Solanum nigram, Oxalis latifolia* dominated the ginger plants and restrict the growth of ginger shoots and rhizome.

PP37

Effect of soft rot disease on growth and yield of ginger

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Ginger (*Zingiber officinale* Rosc.) is a herbaceous plant, the rhizome of which used as a spice and it has anti-inflammatory, antibacterial and antifungal properties. Soft rot caused by *Pythium* spp. is a serious disease of ginger prevalent in all ginger growing areas and affect the rhizome production to the tune of 70%. High soil water, high relative humidity, and relatively low temperature favour the disease development and spread. Buds, roots, developing rhizome, and collar regions are the main points of infection. Rhizomes first turn brown and gradually decompose, forming a watery mass of putrefying tissue enclosed by the tough skin of the rhizome. Roots arising from the affected regions of the rhizome become soft and rot. Foliar symptoms appear as light yellowing of the tips of lower leaves which gradually spreads to the leaf blades. In early stages of the disease, the middle portion of the leaves remain green while the margins become yellow. Subsequently the yellowing spreads to all leaves followed by drooping, withering and drying. Treatment of seed rhizomes with mancozeb (0.3%) for 30 minutes before storage and once again before planting reduces the incidence of the disease. Soil solarization helps in pathogen and disease control, and as a result leads to significant yield increase. Cultural practices such as selection of well drained soils for planting is important for managing the disease. Seed rhizomes are to be selected from disease-free gardens, as the disease is also seed borne. Application of *Trichoderma harzianum* along with neem cake @1 kg/bed helps in preventing the disease.

PP38

Fertigation in ginger is ideal for quality planting material and vegetable ginger production

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Growing crops in soil less medium checks the spread of soil-borne diseases, ensuring a healthy crop and the seed thus obtained can be used as a healthy planting material which is very essential for a good harvest. Fertigation has added advantages such as saving labour and fertilizers which ultimately bring down the cost of production. In the present study, we standardized a soil less medium consisting of coir compost and farm yard manure in 1:1 proportion and also standardized fertigation schedule using water soluble fertilizers for ginger. The results revealed that, 75% of recommended dose of fertilizers (RDF) supplied through fertigation produced significantly higher rhizome yield compared to 100% and 50% RDF supplied through fertigation or 100% RDF applied as solid fertilizers at monthly intervals. But partitioning to rhizomes was significantly reduced

under fertigation treatments compared to application as solid fertilizers. Rhizomes obtained from fertigation treatment had lower starch and fibre content compared to rhizomes obtained from the field (soil) grown crop without fertigation. Hence, fertigation may be more suitable for vegetable ginger production where low fibre and starch are preferred. It can also be used as a nucleus seed material for the production of disease-free plants.

PP39

Infectivity of dry rot pathogen (*Macrophomina phaseolina*) of ginger and its management

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Dry rot and eye rot are two post harvest diseases usually noticed in ginger during storage. These infections are found to be incited by *Macrophomina phaseolina* and *Fusarium oxysporum*, respectively. An experiment was undertaken by artificially inoculating the pathogens individually and in combination and compared with soft rot infection caused by *Pythium myriotylum*. The study revealed that, *M. phaseolina* infects ginger during cropping period and cause rhizome infection manifested as yellowing of the pseudostem and the pathogen causes dry rot during storage. Under pot culture conditions, *Fusarium* did not cause disease whereas inoculation with *M. phaseolina* resulted in 80% incidence as evidenced by yellowing of the plants and *Pythium* caused 100% incidence. In *Macrophomina* challenged pots, the infection appeared only during the post monsoon period which coincided with yellowing of the leaves during maturity. The infected rhizomes externally appeared healthy but on storage the rhizomes shrink and turned into dark charcoal like mass comprising microsclerotia of the pathogen. Among the fungicides, carbendazim and carbendazim –mancozeb were highly effective resulting 100% per cent inhibition of *M. phaseolina* even at 50 ppm. In the case of *P. myriotylum*, metalaxyl - mancozeb, copper oxychloride and Bordeaux mixture showed >70% inhibition *in vitro* at 500 ppm. *In planta* evaluation showed that metalaxyl-mancozeb followed by carbendazim and dimethoate application as the most effective integrated combination in reducing the infections caused by both *P. myriotylum* and *M. phaseolina,* where metalaxyl-mancozeb (0.125%) has to be applied at 30, 60 and 90 days of planting followed by carbendazim (0.2%) and dimethoate (0.05%) at 120 and 150 days.

PP40

Influence of different soil parameters on incidence of ginger rhizome rot and wilt disease complex under hill agro-climatic region of West Bengal

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A study was conducted to find out the influence of different soil parameters (*viz*., electrical conductivity, pH, organic carbon, nitrogen, phosphorus and potassium content) of ginger growing soil on incidence of rhizome rot and wilt disease complex of ginger. Among different parameters

studied, organic carbon content and pH of the ginger soils contributed significantly (93%) in the prediction of ginger rhizome rot and wilt disease complex incidence with negative correlation. Soil having neutral to slightly acidic reaction with OC per cent greater than 2.25 had the low incidence of the disease.

PP41

Knowledge level and attitude of ginger growers towards improved ginger cultivation practices in Tripura

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Ginger is one of the important spice crops with high export value and plays an important role in Indian economy. North Eastern (NE) states of India are prominent for growing various spices including gingeramong which, Tripura contributes a major share both in area and production. A study was undertaken following ex-post facto research design with the sample size of 96 ginger growers selected from South Tripura and Dhalai districts. The study revealed that, majority (62.5%) of the respondents belonged to the middle age group (35-50 years), 37.50% of them belonged to the scheduled tribe category with marginal land holding size and most of them had nuclear type of family with education upto secondary school level. It was also revealed that, all the selected respondents had marketing orientation to sell their produce in the nearby market only. Further, 39.58% of the ginger growers had annual farm income ranging from Rs. 30,000 to 70,000 with 83.33% having medium level of extension contact and 62.5% used various information sources at moderate level and majority (85.2) had very low training exposure on improved cultivation practices. It was also found that, majority (64.58%) had moderate knowledge on various improved cultivation practices. While 100% had knowledge on planting time, only 2.08% had knowledge on pest management. Majority (60.42%) of the respondents had favourable attitude towards adopting improved cultivation practices. The variables age, educational level, extension contact and sources of information utilized were found significant with the attitude of the farmers. The study recommends imparting training and following up of the selected beneficiaries with linkage of farmers' product to the external market to ensure income and prosperity.

PP42

Bionano-silver enhances turmeric germination

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Nanotechnology has the potential to increase nutrient values and also plays a vital role in developing improved systems for monitoring ecological conditions and increasing the capacity of crops to absorb nutrients or pesticides. The use of engineered nanomaterials has increased as a

result of their positive impact on many sectors of the economy, including agriculture. Silver nanoparticles (AgNPs) are now used to enhance seed germination, plant growth, and photosynthetic quantum efficiency and as antimicrobial agents to control plant diseases. In this experiment, we examined the effect of AgNP dosage on the seed germination of turmeric. This experiment was designed to study the effect of AgNPs on germination percentage, germination rate and mean germination time of seedlings. Seven concentrations (0.05, 0.1, 0.5, 1, 1.5, 2 and 2.5 mg/ml) of AgNPs were examined at the seed germination stage. This study showed that exposure to AgNPs caused positive effects on plant growth and germination in turmeric.

PP43

Effect of chemical elicitors on activities of antioxidant enzymes in turmeric (*Curcuma longa* L.)

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Elicitors are substances of biotic or abiotic origin which induce biochemical changes in plants when introduced at low concentrations. Plants respond to these stimuli by activating an array of biochemical reactions, similar to defense responses to pathogen invasions or environmental stimuli, affecting the plant metabolism and enhancing the synthesis of phytochemicals. The present study was undertaken to analyze the effect of three chemical elicitors *i.e.*, chitosan (100, 200 and 500 ppm), salicylic acid (0.01, 0.1 and 1mM) and phenylalanine (0.1, 1 and 10 mM) in two different cultivars (Acc. 849 and IISR Pragati) of turmeric sprayed at 135 DAS (Days After Sowing). IISR pragati accumulated approximately 6% curcumin in its rhizomes whereas Acc.849 accumulated approximately 1%. The activity of catalase (CAT), superoxide dismutase (SOD), polyphenol oxidase (PPO) and peroxidase (POD) were estimated for two consecutive weeks after foliar spray. The results showed that, chitosan had profound effect on the activities of CAT, SOD and PPO whereas phenylalanine increased the activity of POD. The differential response of cultivars to treatments were found as treatments increased CAT and POD activities in IISR pragati whereas Acc.849 responded by increasing SOD and PPO activity. This result when corroborated with rhizome quality parameters may highlight the effect of these elicitors in quality improvement and also in providing protection against vagaries of biotic stresses.

PP44

Effect of integrated nutrient management on yield and economics of turmeric grown in Nagaland

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Field experiments were carried out during 2013 and 2014 to assess the effect of integrated nutrient management on yield and economics of turmeric. The treatments comprised of T_1-Control, T_2 - 100% RDF (80:60:60 kg NPK ha^{-1}), T_3 - FYM (40 t ha^{-1}), T_4 - Pig manure (30 t ha^{-1}), T_5 -

Poultry manure (25 t ha^{-1}), T_6 - Vermicompost (10 t ha^{-1}), T_7 - FYM + biofertilizer, T_8 - Pig manure + biofertilizer, T_9 - Poultry manure + biofertilizer, T_{10}- Vermicompost + biofertilizer, T_{11}- 50% NPK + 50% FYM, T_{12}- 50% NPK + 50% pig manure, T_{13}-50% NPK+ 50% poultry manure, T_{14}- 50% NPK + 50% vermicompost, T_{15}- 50% NPK + 50% FYM + biofertilizer, T_{16}- 50% NPK + 50% pig manure + biofertilizer, T_{17}- 50% NPK + 50% poultry manure + biofertilizer, T_{18} - 50% NPK + 50% vermicompost + biofertilizer). The results revealed that, application of different levels of fertilizers, organic manures and biofertilizer either alone or in combination significantly increased fresh yield of turmeric as compared to control. The maximum fresh yield (48.06 tonnes ha^{-1}) was recorded with the combined application of 50% NPK + 50% poultry manure + biofertilizer, which was closely followed by 50% NPK + 50% vermicompost + biofertilizer (44.05 tonnes ha^{-1}). The highest net return (profit) of Rs. 366410 along with cost benefit ratio of 1:3.20 was also recorded in the treatment of 50% NPK + 50% poultry manure + biofertilizer.

PP45

Integrated crop management fetches more income in turmeric cultivation

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Turmeric (curcuma) - *Curcuma longa* L. (*Zingiberaceae*) is native to Southeast Asia, it has been used since ancient times as a spice, in medicine, and for coloring and flavoring food. India is a leading producer and exporter of turmeric in the world. The national productivity of the crop is 5010 kg ha^{-1}. Production of the turmeric is low in India however; production has to be enhanced to meet the growing demand. Hence an experiment was conducted at ICAR-IISR to compare the yield of turmeric obtained under different crop management systems such as organic management, integrated management and Inorganic (100%) management using the turmeric varieties Prathibha and Aleppey Supreme for a period of four years (2012-2016). The experiment was laid out in Randomized Block Design with eight replications. The result showed that integrated crop management recorded more yield (24.56 t ha^{-1}) and net income (4.27 lakhs ha^{-1}) compared to organic crop management (20.63 t ha^{-1}). Maximum curcumin (5.67%) was noticed in organic management. Physicochemical properties of turmeric soil revealed that maximum availability of calcium, potassium, nitrogen, and magnesium in organic crop management followed by integrated management whereas yield of turmeric and net income obtained was less in organic management.

PP46

Intercropping in turmeric: A low cost cultivation practice for higher returns

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Turmeric (*Curcuma longa*) is a herbaceous plant belonging to family *Zingiberaceae*. It is an important spice as well as medicinal plant. Turmeric is grown for its rhizomes, which have many uses. It is used in the preparation of cosmetic goods, medicines and food industries, etc. It is also used as a main ingredient in Indian culinary as curry powder. Turmeric is extensively used as stimulant, blood purifier, remedy against skin diseases, pain etc. Intercropping is one of the most common practices used in sustainable agricultural systems which have an important role in increasing the productivity and stability of yield in order to improve resource utilization and environmental factors. Turmeric is a slow growing crop at its early growth phase, providing opportunities for being used under intercropping system. Due to its slow growing habit during early growth stages, it does not cover the soil very fast and the solar energy remains unutilized. This offers good scope of growing intercrop which helps in utilizing the solar radiation during period of slow growth rate in the initial growth stage of turmeric. Hence, the space between turmeric rows can be efficiently utilized by growing short duration crops like annual spices, vegetables, cereals and pulses, which do not affect growth, yield and the characteristic attributes of turmeric. In the last few decades intercropping with turmeric commercially adopted by farmers due to its advantages for yield increment, weed control, insurance against crop failure, low cost of production have resulted in high monetary returns to the farmers.

PP47

Diseases and pests of turmeric - A foray into Andhra Pradesh and Telangana

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Turmeric [*Curcuma longa* L.], the age old spice has recently gained global attention because of its innumerable medicinal properties. India accounts for about 78% of world's turmeric production and Andhra Pradesh and Telangana own major share of both area (38.64%) and production (58.98%) in India. This study is based on extensive field surveys conducted in Guntur and Krishna districts of Andhra Pradesh and Nizamabad, Karimnagar and Jagtiyal districts of Telagana with a focus on understanding the extent of biotic stresses on cultivated turmeric and their economic implications. Turmeric grown in surveyed locations was mainly infected by rhizome and root rot, and foliar diseases. Rhizome rot affected plants showed yellowing of leaves starting from lower leaves, graduallly spreading to the upper parts and water soaked dark brown lesions on the collar region which enlarge rapidly resulting in drying. Root knot nematode (*Meloidogyne incognita*) infestation in turmeric was noticed where rhizome and root rot incidences were severe. Association of maggots of *Mimmegrella coeruleifrons* was also observed with rot affected plants. The incidence of foliar diseases was found to be very high (60-80%) with the severity ranging from 10-40%. Indiscriminate, unscientific and unsafe use of plant protection chemicals were very common in surveyed plots. The study warrants the need for a sensitization drive on integrated plant protection strategies among field functionaries and farmers to address the indiscriminate use of pesticides. Other interventions like strategically placed field demonstrations and awareness programmes are also essential for realizing substantial savings in cost of cultivation as well as increase in returns from turmeric farming in Telangana and Andhra Pradesh.

PP48

Air layering, a new technique for propagation in nutmeg (*Myristica fragrarns* Houtt.)

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Nutmeg (*Myristica fragrarns* Houtt.) is an important, dioecious tree spice which gives two spices, the nutmeg kernel and mace. As the true seedlings segregates into male: female (~50:50), commercial propagation of the tree is mainly done through vegetative methods such as grafting and budding which needs skill and experience for reasonable success.

Air layering as a viable propagation technique is not attempted seriously in nutmeg though it is a cost effective and easy method of propagation. Taking a cue from the ability of the tree to naturally produce aerial roots, air layering was successfully attempted for the first time in orthotropic and plagiotropic shoots of 15-30 year old nutmeg with 75% survival. The root initiation was observed in about 75-90 days and the air layered shoots in the periphery of the canopy showed 100% rooting irrespective of whether it is of orthotropic or plagiotropic in nature. However the shoots inside the canopy (under heavily shaded areas) failed to root and gradually dried up. The root initials were thick and grew rapidly producing thinner secondary and tertiary roots within a month. The air layered shoots were detached from the trees after four months, planted in polythene bags and hardened inside a humid chamber for 20-30 days. The layers were maintained for another one month in nursery after removing from the hardening chamber and planted in the field. All the air layered plants were established and showed normal growth under field conditions.

PP49

Effect of shade on the growth and nutrient content in Mexican Coriander (*Eryngium foetidum*)

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An experiment was conducted in the year 2017-18 at College of Horticulture and Forestry, Pasighat, Arunachal Pradesh to investigate the effect of different shade conditions in the growth, nutritional and medicinal properties of Mexican coriander under Pasighat condition. Three different treatments and a control were used for the experiment *i.e.* shade conditions of 25%, 50%, 75% and control (open condition). The data was recorded at the time of harvesting (90-100 days after transplanting). It was observed that, there was significant difference in the performance of the crop morphologically, in terms of nutrient content and phytochemicals at different shade conditions. The performance of the crop was best under 75% shade with higher plant height and plant spread as compared to other treatments.

PP50

Comparative economic analysis of FLD and non-FLD cumin growers in rainfed conditions of Rajasthan, India

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The present study was carried out in Pali district, Rajasthan to compare the economics of FLD and non-FLD approaches adopted among the cumin growers under rainfed conditions. A multistage random sampling technique was adopted for selection of blocks, villages and sample farmers. From each village, 16 FLD farmers cultivating cumin and 16 non-FLD farmers cultivating local cultivars of cumin were selected, thus making a total sample of 80 farmers each for FLD and non-FLD. For evaluation, primary data were collected from the sample farmers by survey methods with the help of well-designed interview schedule by personally contacting the sample farmers. The results indicated that, FLD farmers were relatively younger than non-FLD farmers, who readily accepted the FLD cumin technology. FLD cumin growers obtained higher yields (10.86 q/ha) compared to non-FLD cumin growers (5.09 q/ha). The benefit cost ratio was also higher for FLD farmers (3.09) as compared to non-FLD farmers (1.09). The partial budgeting analysis suggested that farmers could benefit to the tune of Rs. 86500/ha by adopting FLD cumin technology. Further, the study indicated that, there has been rapid expansion of area under of FLD cumin registering an impressive growth of 78.99% during the last decade (2007-2008 to 2016-17).

PP51

Eco-friendly management of sucking pests infesting cumin

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Cumin (*Cuminum cyminum* L.), an important spice crop, which is cultivated mostly in arid and semi-arid regions of Gujarat and Rajasthan. Cumin is mainly attacked by number of insect pests both in the field as well as in storage conditions among which, cumin aphid, *Myzus persicae* and cumin thrips, *Scirtothrips dorsalis* are the major ones. A field experiment was conducted at Seed Spices Research Station, Jagudan during *rabi* 2016-17 with an objective to develop eco-friendly management strategies for sucking pest management in cumin. The treatments comprised of *Lecanicillium lecanii* 1.15 WP (1x10^9 cfu/gm) @40 g/10 lit., Azadirachtin 300 ppm @50 ml/10 lit., NSKE @5%, Azdirachtin 1500 ppm @40 ml/10 lit., Azadirachtin 10000 ppm @30 ml/10 lit., *Beauveria bassiana* (1 x10^9 cfu/gm) @40 g/10 lit., Botanical Insecticide Soap @20 g/lit., Karanj oil @20 ml/10 lit.+ 0.1% Soap solution, *Ipomoea* 10% leaf extract and untreated control. The results revealed that, *L. lecanii* registered the least aphid infestation at seven days after second spray (6.51%) followed by Azadirachtin (9.69%). Mean population of thrips differed significantly among different treatments. However, mean population of thrips varied from 8.62 (*L. lecanii*) to 24.83 (untreated control) per plant at seven days after second spray. The mean population of predatory coccinellids varied from 1.85 (Azadirachtin) to 3.25 (untreated control) per plant at seven days after second spray. Seed yield of cumin differed significantly among different treatments. Among

them, *L. lecanii* recorded the highest seed yield (160 kg/ha) and remained significantly superior over other treatments. The treatments, *B. bassiana* and Azadirachtin registered 120 kg/ha and 113 kg/ha seed yield, respectively.

PP52

Effect of *ex-situ* moisture conservation practices in cumin under dryland condition

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Sustained economic growth and increasing urbanization are fueling rapid growth in the demand of high value food commodities like spices, fruits, vegetables, milk, meat, egg and fish. Moving on to non- traditional area for cultivation can provide a remunerative solution for further enhancing the farmer's income. The non-traditional areas may include shifting orientation from cereal dominance to high value spice crops like; cumin, fennel, and coriander, Ajawain *etc*. In the present study, an attempt was made to examine the impact of different methods of sowing and irrigation in cumin during *kharif* 2012-13 to 2014-15 on medium black to sandy loam soils and to find out the effect of climate change on *ex-situ* conservation of rain water at on-farm in participatory action research mode under dryland conditions. The data indicated that, the practice of two supplemental irrigations in cumin crop exerted significant influence on seed and stalk yields. On the basis of pooled results, the practice of supplemental irrigation recorded significantly higher seed as well as stalk yields of cumin *i.e.* 597 and 684 kg/ha as compared to farmers practice (426 and 507 kg/ha), respectively. Further, higher net return (Rs. 79392/ha), benefit cost ratio (7.56) and rain water use efficiency (0.94 kg/ha.mm) were secured with application of supplemental irrigation.

PP53

Boosting fennel production through front line demonstrations in rainfed conditions of Rajasthan, India

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Front line demonstrations with fennel variety RF-125 were conducted in farmer's field in Pali district (Rajasthan) during 2013–2017 *Rabi* season. The increase in grain yield under demonstration was 14.8 to 33.15% compared with local practices. An yield advantage of 28.15 per cent was recorded under demonstrations carried out with improved cultivation technology as compared to farmers' traditional way of fennel cultivation. The extension gap was lowest (200 kg/ha) during 2013-14 and was highest (477 kg/ha) during 2015-16. Wide technology gap was observed during different years which was lowest (238 kg/ha) during 2013-14 and highest (511 kg/ha) during 2014-15. On four years average basis, the technology gap of total 105 demonstrations was found to be 521 kg/ha. The difference in technology gap during different years could be due to more feasibility of recommended technologies during different years. An additional investment of Rs. 1275.3 per ha coupled with scientific monitoring of demonstrations and non-

monetary factors resulted in additional returns of Rs. 4578 per ha. Fluctuating sale price of fennel during different years influenced the economic returns per unit area. The incremental benefit cost ratio was found as 3.7. It is concluded that, front line demonstration programmes were effective in changing the attitude, improving skill and knowledge on recommended practices of fennel cultivation including adoption.

PP54

Production and export performance of seed spices in India

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Seed spices are the major constituents of spice economy of India. Cumin, coriander, fenugreek, fennel, ajwain, celery, anise, nigella, dill and caraway are the seed spices cultivated in India. Out of these, first five had the lion's share of 51 and 21% of total spice area and production in the country during 2015-16. In the recent past, role of seed spices in total spices has increased. During 1985 and 2015, total spice production in the country increased by 3.4 times from 18.21 to 69.02 lakh tons at a compound growth rate (CGR) of 4.5% as result of almost doubling of productivity and also acreage. In the same period, seed spices production has increased six times from 2.47 to 14.69 lakh tons at the CGR of 5.4% per annum as their acreage has tripled coupled with productivity improvement. The area share of cumin, fenugreek, fennel and ajwain to total spices has increased in this period, indicating the increasing passion for seed spices among the farmers. Production of cumin, coriander, fennel and fenugreek increased by 5.81, 2.86, 5.13 and 1.93 times at CGR of 7.49, 3.52, 10.01 and 5.6% per annum, respectively. There was setback to coriander and cumin area and production during 1995-2005, but registered good recovery during 2006-15 with more than 7 and 12% growth in area and production respectively, whereas productivity has shown continuous increase as result of positive impact made by R&D in both seed spices. Fenugreek area and productivity in the country has shown continuous increasing trend in last thirty years. Production in all the seed spices was measured with more instability than their area and productivity, has decreased over the study period, indicating consistent growth in recent period. In this period total spice export increased by 9 and 66 times in quantity and value term respectively, at CGR of 8 and 16% respectively. Because export to production share has improved from 5.1 to 13.7% in total spice, from 4.7 to 8.3 in coriander and from 4.9 to 30.3 in cumin. Consequently, share of seed spices to total spice export has tripled in value term and doubled in volume due to faster growth in coriander (11.10% in quantity and 19.50% in value) and cumin (17.25% in quantity and 25.35% in value) export than total spice export (8.23% in quantity and 15.69% in value) from India. Study concludes that seed spices are gaining more weightage among farmers and in export basket of Indian spices.

PP55

In vitro studies on potential of *Trichoderma* in managing Naga King Chilli diseases

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Capsicum chinense Jacq. locally known as Raja Mircha or Naga King Chilli is one of the important spices of Nagaland, cultivated in an area of 1000 ha with a total production of 6,000 metric tonnes. The Naga King Chilli, despite its reputation, is very sensitive and vulnerable crop and suffer from several diseases. In 2016, an investigation was carried out to study the potential of different species of *Trichoderma* in managing diseases of Naga King Chilli. Four pathogens *viz*., *Colletotrichum capsici* (anthracnose), *Fusarium oxysporum* (Fusarium wilt), *Sclerotium rolfsii* (stem rot) and *Rhizoctonia solani* (damping off) were isolated from infected Naga King Chilli plants. Five *Trichoderma* spp. *viz*., *T. asperellum, T. harzianum, T. koningii, T. virens* and *T. viride* were screened against the pathogens under *in vitro* conditions following dual culture plate technique. Among the *Trichoderma* spp., *T. harzianum* recorded highest mycelial growth inhibition against *C. capsici* (79.61%). Whereas, *T. koningii* and *T. viride* were promising against *F. oxysporum* (100%) and *T. harzianum* against *S. rolfsii* (85.07%). *T. koningii*, *T. viride*, *T. harzianum* and *T. virens* were equally effective against *R. solani* with a mycelial growth inhibiton of 92.20%.

PP56

Comparison of pest incidence of capsicum (*Capsicum annuum* L. var. *grossum* Sendt.) in open, shade and polyhouse conditions in Telangana and Andhra Pradesh

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Fixed plot surveys in and around Hyderabad, Telangana and roving surveys were conducted in Andhra Pradesh during 2013-14 to analyze the pest incidence in capsicum cultivated under open, shaded and polyhouse conditions . Surveys in Telangana revealed that, thrips, *Scirtothrips dorsalis*; mites, *Polyphagotarsonemus latus;* cut worm, *Agrotis ipsilon*; blossom midge, *Asphondylia capsici* and fruit borer, *Spodoptera litura* were prevalent under open field conditions whereas, aphids and whiteflies were widespread in addition to above insect pests under polyhouse conditions. During the cropping season 2013-14, the mean population of thrips (no./leaf) ranged from 9.60 ± 0.47 to 12.24 ± 1.20 and mites from 5.94 ± 0.79 to 10.64 ± 2.34. The per cent damage per plant caused by cut worm, blossom midge and fruit borer ranged from 2.12 ± 0.78 to 5.33 ± 0.56, 2.75 ± 0.49 to 9.26 ± 3.19 and from 5.26± 0.91 to 17.8 ± 3.89, respectively under open field conditions. In polyhouse, the mean population of thrips, mites, aphids and whiteflies ranged from 1.87 ± 0.66 to 4.99 ± 1.75, 1.10 ± 0.65 to 4.56 ± 1.42, 0.68 ± 0.77 to 2.94 ± 2.06 and from 0.05 ± 0.3 to 1.13 ± 0.45, respectively. The per cent damage per plant caused by cut worm ranged from1.01 ± 0.70 to 4.04 ± 0.98, blossom midge, from 0.66 ± 0.59 to 4.05 ± 1.53 and fruit borer, from 1.03 ± 0.59 to 5.42 ± 0.8181, respectively during the cropping season. Population levels of insect pests and expected per cent

yield loss were higher under open field conditions, moderate in shade net conditions and lowest in polyhouse conditions.

PP57

Effect of weed management practices on quality and seed yield of nigella (*Nigella sativa* L.)

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Nigella (*Nigella sativa* L) is a minor and annual herbaceous seed spice crop belonging to the family Ranunculaceae. Being a slow growing seed spice, it is more prone to crop weed competition. The present study was carried out to evaluate economic feasibility of weed management practices in nigella. The results indicated that, significantly higher plant height, number of primary and secondary branches per plant were recorded with the pre-emergence application of oxadiargyl @75 g /ha + one hand weeding (HW) at 45 days after sowing (DAS) and pendimethalin @1 kg /ha + one hand weeding at 45 DAS. Similarly, yield attributes like number of siliqua per plant, number of seeds per siliqua, siliqua size and test weight as well as seed yield of nigella were also higher with these two treatments. The maximum chlorophyll 'a' 'b' and total chlorophyll and carotenoids content were recorded with weed free treatment followed by oxadiargyl (PE) + HW at 45 DAS, oxadiargyl at 20 DAS + HW at 50 DAS as compared to weedy check. Besides weed free treatment, lower dry weight of weed at harvest, weed index with highest weed control efficiency was obtained under pre–emergence application of oxadiargyl +one hand weeding at 45 DAS. The highest gross and net returns per ha were obtained in weed free treatment followed by pre - emergence application of oxadiargyl + one hand weeding at 45 days after sowing but highest B: C ratio (2.62) was recorded with pre- emergence application of oxadiargyl + one hand weeding at 45 DAS.

PP58

Characterization, host adaptability and hybridity of divergent *Phytophthora* species in spices - plantation crops based agricultural systems

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Spices and plantation crop sector plays substantial role in our national economy. Spices - plantation crops based cropping systems though proved to be profitable, it often provide conducive micro-climate for proliferation of pathogens inciting a variety of diseases by diseases. In the present study, 12 *Phytophthora* isolates (13-01, 13-13, 13-16, 13-32, 12-31, 12-30, 12-15, 12-19, 98-02, 98-93, 05-06 and 01-03) representing different species (*P. capsici, P. tropicalis, P. palmivora* and *P. meadii*) and hosts (black pepper, cardamom, nutmeg, coconut, arecanut and cocoa) were obtained from National Phytophthora Repository, ICAR-IISR, Kozhikode and characterized for cultural (colony growth rate and colony pattern), morphological (sporangial, sporangiophore and

chlamydospore) and biological (cross infectivity, hybridity and hyphal anastomosis) characteristics. Cultural characteristic revealed that colony growth rate ranged from 32.7 to 93.1 mm day^{-1} and five different types of colony patterns *viz.,* cottony, floral, stellate, stellate cottony and floral cottony were observed. *Phytophthora* species varied in sporangial characteristics also. Cross infectivity assay proved that, few isolates were capable of infecting host species other than their principal host. Mating type determination studies revealed that, some of the isolates were sexually compatible with others representing different crop species. Hyphal/vegetative compatibility studies indicated that two type of interactions *viz.,* type 1 (formation of 'H'-like interconnecting structures) and type 2 (parallel growth and dissolution) in the isolate 13-01. The resuts indicated that, considerable variability exists in *Phytophthora* population, besides having potential for host adaptability and inter-specific hybridity.

SESSION IV:
POST-HARVEST MANAGEMENT, VALUE ADDITION AND MARKETING OF SPICES

LEAD LECTURES

Spice processing: An innovative scientific approach to a profitable future

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Since ancient times, India has been the house of many important spices like black pepper, cardamom and ginger. India, with its favourable climatic and soil conditions for growing spices, is the largest producer and consumer of spices. India produces around 5.8 million tonnes of different spices annually. During 2014-15, it was estimated that India exported spices and spice products earning around Rs. 17665 crores (US$2633.30 million) in foreign exchange.

Though India is a major producer of spices, not much attention has been paid to improvement in the quality of whole dry spices. The importing countries are very particular about standards relating to safety and hygienic quality in the spices including the absence of foreign material. Of late, in international trade, much emphasis is being laid to microbial load, pesticide residues and heavy metal contamination.

Primary processing of spices

Harvesting

Spices are usually harvested when they are fully matured. For some spices harvesting is done at different stages of maturity to meet specific needs of the end product. In the case of black pepper, fully matured spikes are harvested for making black pepper or white pepper, whereas immature pepper (7-8 months old) is harvested for use in canned pepper, pepper in brine and dehydrated green pepper. In the case of chilli, in India, fully matured fruits are harvested manually. They are heaped for a day or two for proper development of the red colour and then sundried. In Japan, harvesting is done mechanically, either by cutting the whole plant or branches. Chilli is destalked before drying. This helps in faster drying and also there will be no spillage of seeds. In ginger, fully matured green rhizomes are harvested for use as fresh spice or converted into dry ginger. This dry ginger is used for making powder and also in oil and oleoresin extraction. On the other hand, tender and less fibrous ginger is preferred for making products like candy, preserve, pickles *etc*. In the cases of cardamom and turmeric, fully matured spices are harvested and suitably processed.

Drying

After harvesting drying is the most important step.

i. Sun drying is very commonly practiced. Spices are dried on mats or on mud yards. Here contamination from soil and other extraneous sources can take place.
ii. An improvement over this is drying the spices on raised cement platforms. Here contamination from soil is eliminated.
iii. As further improvement over this, the cement yards are covered with nylon nets which help in preventing contamination from birds excreta and other extraneous matters. Mechanical drying for some spices is employed which helps in getting safe and hygienic products, but it will be costlier than sun drying.
iv. Newer methods of drying include microwave heating and infrared heating especially in case of herbs were most of its bioactive components needs to be retained during processing has been developed. Electromagnetic radiation finds application ranging from blanching, drying, backing and roasting of herbs. As this is a dry heating process, much valuable nutrients can be conserved which may be lost during blanching.

Secondary processing

Primary processing of the spices should result in a clean and sound spice free from microbial contamination, aflatoxin, insect infestation, metal contamination and pesticide residues. Quality control of dried spices is monitored by the cleanliness specification prescribed by national and international organizations/acts like Prevention of Food Adulteration Act (PFA) and American Spice Trade Association (ASTA). Fumigation and irradiation techniques are used as a control measure for the elimination of microbial and insect contamination. Adulteration plays an important role in determining the quality of a spice. Quality is a complex term to define and it would vary with the consumer's needs. Quality can be deemed to comprise of physical, chemical, microbiological and sensory attributes. Cleanliness specifications as prescribed by the ASTA for various spices and herbs are given in table 1. Besides this, lot of emphasis is laid on the microbial quality of spices. Contamination of spices by heavy metals like lead, zinc, copper, mercury *etc*. are also likely to pose problems in external and internal trade. Similarly, residual pesticides on the spices pose health hazards to the consumers.

Table 1. Cleanliness specification for spices, seeds and herbs

Name of spice, seed of herb	Whole insect, dead by count	Excreta mammalian by mg/Lb	Excreta other by mg/Lb	Mold By Wt	Insect defiled/ infested % by wt	Extraneous/ foreign matter % by wt
Allspice	2	5	5.0	2.0	1.00	0.50
Anise	4	3	5.0	1.00	1.00	1.00
Sweet basil	2	1	2.0	1.00	1.00	0.50
Caraway	4	3	10.0	1.00	1.00	0.50
Cardamom	4	3	1.0	1.00	1.00	0.50
Cassia	2	1	1.0	5.00	2.50	.50
Cinnamon	2	1	2.0	1.00	1.00	0.50
Celery seed	4	3	3.0	1.00	1.00	0.50
Chilli	4	1	8.0	3.00	2.50	0.50
Cloves	4	5	8.0	1.00	1.00	1.00
Coriander	4	3	10.0	1.00	1.00	0.50
Cumin seed	4	3	5.0	1.00	1.00	0.50
Dill seed	4	3	2.0	1.00	1.00	0.50
Fennel seed	-	-	-	1.00	1.00	0.50
Ginger	4	3	3.0	-	-	1.00
Laurel leaves	2	1	10.0	2.00	2.50	0.50
Mace	4	3	1.0	2.00	1.00	0.50
Marjoram	3	1	10.0	1.00	1.00	1.00
Nutmeg (broken)	4	5	1.0	-	-	0.50
Nutmeg (whole)	4	0	0.0	-	-	0.00
Oregano	3	1	10.0	1.00	1.00	1.00
Black pepper	2	1	5.0	-	-	1.00
White pepper	2	1	1.0	-	-	0.50
Poppy seed	2	3	3.0	1.00	1.00	0.50
Rosemary laves	2	1	4.0	1.00	1.00	0.50
Sage	2	1	4.0	1.00	1.00	0.50
Savory	2	1	10.0	1.0	1.00	0.50
Sesame seed	4	5	10.0	1.0	1.0	0.50
Sesame seed (hulled)	4	5	1.0	1.0	1.00	0.50

Tarragon	2	1	1.0	1.0	1.0	0.50
Thyme	4	1	5.0	1.00	1.00	0.50
Turmeric	3	5	5.0	3.00	2.50	0.50

Microbiological quality of spices

Spices are known to harbour various types of microorganisms, which are either of spoilage significance or public health significance. Spices at the time of harvest contain moisture up to 83%, which must be brought down to a safe moisture level of 8-12% from the microbiological point of view. It is possible that spices get contaminated at any step during processing. The primary processing of spices should not only ensure the retention of valuable properties of the spice like flavour, colour and pungency but also its hygienic quality. Mould growth would occur in spices if not dried properly and in a few cases the problem of aflatoxin has been noticed. According to PFA, the maximum permitted level of aflatoxin is 3 ppb. Spices meant to be used as table condiments should be free of *Salmonella* and other microbial pathogens. Thermophyllic spore formers could cause spoilage of canned foods. In dry spices, major components of microflora constitute aerobic spore formers. Black pepper is a major source of aerobic spore forming bacteria and many of them are heat resistant and hence is a dominant survival organism in inadequately heat processed products. In order to improve the microbial quality of spices, it is necessary to take adequate precaution at each stage of processing.

Irradiation

Gamma irradiation has been found to be extremely reliable and effective in controlling or eliminating microbial as well as insect populations. BARC has carried our extensive research on disinfestations of whole and ground spices. It has been found that, a dose of 5 kGy could bring down the number of bacteria in spices to below 10^3 to 10^4 organisms per gram, a requirement imposed by several important countries. This dose was also found to completely eliminate the fungi in spices. A dose of 10 kGy is recommended by the joint FAO/IAEA/WHO expert committee for the treatment of spices. The US FDA has now cleared doses up to 30 kGy for disinfestations of spices, seasonings and blends of the same. Twenty eight countries have cleared the use of gamma irradiation for sterilization of various food materials. Recently, Government of India has given clearance for the use of gamma irradiation for disinfestations of spices and spice products.

A thermal sterilization technology developed at CFTRI without the use of chemicals has been found to reduce the microbial load in pepper samples significantly. Water used in processing of spices, in operations such as soaking, washing, boiling *etc.* should be of potable quality. The pH or hardness of water is not a critical factor in operations such as soaking or cleaning. However, the quality of water assumes importance in the preparation of products like canned or bottled green pepper and also cleaning of dry spices to reduce the microbial load. Major spices of commercial importance and also from export point of view include spices like black pepper, ginger, turmeric, chilli and large/small cardamom with special reference to North East region.

Black pepper

Black pepper is obtained from a perennial climbing vine, *Piper nigrum* (Piperaceae) and is native to Southern India. It is now cultivated in India, Indonesia, Malaysia, Sri Lanka and Brazil. In India, the plant flower during June - July and the spikes are ready for harvest by about January - February the next year. When the berries are fully matured, the spikes are cut off. The berries are then separated from the stalk either manually or mechanically. The separated berries are dried under sun for 5 - 6 days to get black pepper. Finally, the pepper is cleaned to remove stems, husk and pinheads. About 40,000-50,000 tonnes of black pepper is being produced annually in India. Black pepper has a characteristic spicy odour and a biting taste. The aroma is due to volatile oil and the pungency to an alkaloid piperine. Black pepper normally contains moisture 10-12%; 8-10% crude fibre and 3 - 6% piperine.

White pepper: It is produced by removal of the outer skin or pericarp of the berries by using any one of the following techniques: i. Water steeping ii. Boiling in water iii. Chemical treatment and iv. Decortication. Red ripe berries, fully matured green pepper or black pepper can be used as the starting material. A yield of about 22 kg per 100 kg of fresh pepper is obtained. White pepper powder is used in the production of mayonnaise and salad dressings. World trade in white pepper is about 25,000 tonnes.

Green pepper: It is made from immature green pepper. Fresh green berries are subjected to heat treatment and then mechanically dried under controlled conditions. When dried, these give green pepper which has a fresh spicy flavour and reconstitutes easily in hot water. Annually about 150-200 tonnes of dehydrated green pepper is exported from India.

Canned green pepper: It is made from cleaned pepper berries packed in cans, covered with hot 2% brine containing 0.2% citric acid, exhausted at 80^{o}C, sealed and processed in boiling water for 20 minutes and then cooled in cold water.

Bottled green pepper: It is made from cleaned pepper berries packed in bottles and covered with 20% brine containing 100 ppm SO_2 and 0.2% citric acid.

Pepper oil: This is obtained by steam distillation of the ground pepper. This oil is responsible for the characteristic spicy odour of pepper; the oil is made up of monoterpenes (70-80%), sesquiterpenes (20-30%) and oxygenated compounds (5%). The oil is used in food flavouring and perfumery.

Pepper oleoresin: This represents the total flavour of the spice and is obtained by solvent extraction of the ground pepper. Yield and quality of oleoresin are dependent on the type of raw material and solvent used. The oleoresin is made up of volatile oil, pungent principles, fixed oil, resins, colouring matter *etc*. Pepper oleoresin is also made by using super critical extraction technique. Pepper oleoresin is used in meat industry and also in savoury foods like pickles, sauces, soups, gravies, chutneys and dressings.

Ginger

Ginger is grown in almost all parts of India mainly in the hilly regions and is consumed widely as flavouring component in culinary preparations, in certain beverages and medicinal preparations. Fresh ginger is always available round the year coming from one region or other. Kerala, Tamil Nadu, States in North Eastern region like Assam, Meghalaya and Tripura are the major producers of ginger. Apart from trading as fresh ginger it is also made available as dry ginger and traded far and wide as a commercial product. A few value added products can be made in the organized and home/rural sector from ginger which can find market everywhere including in remote places.

Fresh ginger is often sun - dried as such or after partial peeling which facilitates drying. In Jamaica, it is completely peeled and dried. Bleached ginger is made by soaking fresh ginger rhizomes in 2% lime water for 6 - 8 hours. They are then removed and fumigated with sulphur fumes and dried. The process is repeated 2-3 times. This treatment, besides giving a white appearance, prevents attack by insects. Ginger contains on an average, moisture 10%, protein 8.3%, volatile oil 2%, NVEE 3.9% and starch 60%.

Ginger oil: This is obtained by steam distillation of the ginger powder. The characteristic pleasing aroma of ginger is due to its essential oil, which is present to the extent of 1-3% in the dried spice. The essential oil in ginger is a complex mixture of terpenoids. The oil is used as a flavouring material for various beverages, both alcoholic and non-alcoholic and perfumes.

Ginger preserve and candy: Fresh tender ginger or fibreless variety is used for this purpose. The ginger is peeled and cut into desired shape or size, cooked in 0.5% citric acid solution for one hour and then cooled. The ginger pieces are then impregnated with 30^{o} Brik syrup. The process of syrup impregnation is carried out using higher strengths of syrup over a period of time. The preserve is then ready. Candy is made by taking out the ginger pieces from the syrup and rolling in finely ground sugar. The sugarcoated pieces are then shade dried.

Turmeric

Turmeric is the dried rhizome of *Curcuma longa* L. (Zingiberaceae), a herbaceous plant native to tropical South East Asia. Allied minor *Curcuma* species include *Curcuma aromatica*, *Curcuma xanthorhiza*, *Curcuma zedoaria*, *Curcuma amada* and *Curcuma cassia*. Turmeric has a deep yellow colour and pungent aromatic flavour and finds application as a spice and as food a colourant.

India is the major producer of turmeric. Other producing countries are Bangladesh, Indonesia, China, Sri Lanka, Taiwan and Jamaica. In India, it is mainly cultivated in Andhra Pradesh, Maharashtra, Odisha, Tamil Nadu, Bihar, Kerala, Assam, West Bengal, Karnataka and Tripura. Most of the turmeric produced in India is consumed locally and only about 8% is exported. Turmeric is propagated by small portions of the rhizomes, and becomes ready for harvest 7-9 months after planting. In India, planting is usually done during the period, June to August and harvesting is done during February to April.

Harvesting and processing: Drying of the plants including the base of pseudostem indicates maturity. In one practice of harvesting, the leaves and stems are cut close to the ground, the field is irrigated to facilitate digging out and the rhizomes are carefully lifted and washed thoroughly to remove adhering soil. The yield of raw turmeric varies from 16.8 to 22.4 tonnes per hectare. Some common cultivars of turmeric grown in India are Amruthapani, Armoor, Duggirala, Tekkurpeta, Rajapuri Karhadi, Waigon, Alleppey, Wayanad and Chinnanadan.

Preparation for the market: About 15 to 20% of the harvested rhizomes are retained by the farmer as seed material and the rest is marketed by first separating into mother rhizomes and fingers. Roots hairs, poorly developed and shriveled portions are removed. The bulbs and fingers are separately processed by curing, sun drying and polishing.

Curing is essentially a process of cooking the raw rhizomes in water till it becomes soft (about 40 minutes for a 90 kg lot). Cooking gives the fingers a uniform colour; the starch gets gelatinized and the time of drying is considerably reduced. Cooked turmeric is spread on prepared yards and dried under sun for 10-15 days. Dried turmeric usually has a low moisture content of about 6%. It gives a metallic sound when broken, the dried turmeric (dry yield being usually 20-25%) is polished by manual or mechanical rubbing. Mechanical polishing drums have been developed to handle small or large batches. By polishing, the scales, rootlets and some of the epidermal layer are removed; the rough and dull appearance changes to a smooth surface of brownish yellow colour. The surface colour can be further improved by external coating with turmeric powder. Lead chromate, a poisonous chemical has been wrongly employed by some people to impart bright yellow colour to turmeric. However, its use is prohibited under law. Dried turmeric is transported to assembling markets, polished if required and stored in gunny bags in warehouses, periodical fumigation is necessary, as the hard dry turmeric is quite susceptible to insect infestation.

Grading of turmeric: Turmeric is graded mainly for the export market under the AGMARK specifications. In India, law before export prescribes quality pre-inspection of all turmeric. Specifications have been prescribed under the following grade designations: A. Fingers (general) – special, good, fair; B. Fingers (Alleppey) - good, fair; C. Fingers Rajpore – special, good, fair; D. Bulbs – special, good, fair. In both fingers and bulbs, a grade denoted 'non-specified' is provided to cover product not covered by other graded and exported only against firm agreement and orders. The biggest importers of turmeric are countries like USA, Japan, Singapore, Canada, Netherlands, UK and Australia. Cured and dried turmeric is marketed as bulbs and fingers and each type in polished and unpolished forms. Splits are bulbs which have been cut into halves or quarters before curing to facilitate subsequent drying. There are 16 major regional types recognized in the internal trade in

India. They are related to traditional and familiar sources and nearness of market to production centers.

Composition of turmeric: Turmeric contains on an average moisture 6%, protein 6.5%, fixed oil 3.5%, volatile oil 4.5%, crude starch 50.4%, fibre 3% and curcumin 3.1%. Alleppey turmeric contains 6 - 8% curcumin. Standards specify that, ground turmeric to contain not more than 7% total ash, 1.5% insoluble ash and 60% starch. The volatile oil obtained by steam distillation of ground turmeric is pale yellow to orange yellow in colour, with an odour reminiscent of the fingers. More than 50% of the oil is composed a mixture of sesquiterpene ketones, known as turmerone and about 25% of the sesquiterpene zingiberene. Other constituents reported include d-1-phellandrene (1%), d-sabinene (0.6%), cineole (1%), borneol (0.5%), sesquiterpene alcohols (6.9%) and traces of alpha and gamma lactones. Turmeric oil has a very limited use in food flavouring and perfumery and is not commercially important.

Turmeric pigment: The most valued constituent of turmeric is its yellow pigment, curcumin. The colouring matter is extractable using solvents like methanol, ethanol and acetone and dichloroethylene but not by petroleum solvents. The water insoluble pigment is chiefly curcumin (bis – feruloyl methane) besides, two cogeneric pigments, p-hydroxy cinnamoyl feruloyl_methane and bis (p-hydroxy cinnnamoyl) methane and many minor uncharacterized pigments.

Processed products:

i. **Ground turmeric:** Turmeric is consumed mostly in the ground form to give foods an attractive yellow colour and characteristic spicy flavour. Turmeric powder is used worldwide for domestic culinary purposes. It is an important ingredient of curry powders and mustard paste. It is also used in the flavouring poultry, sea foods, rice dished and sauces.

ii. **Turmeric oleoresin:** Like other spice oleoresins, turmeric oleoresin is made by solvent extraction of the powdered spice followed by removal of the solvent to get a viscous resinous preparation containing all the flavouring principles including the volatile oil and active ingredients. In addition, non-volatile fatty and resinous materials and waxes extractable by the solvent are also present. Curcumin constitutes about one third of a good quality oleoresin. Turmeric oleoresin is mixed with a suitable solubilizer like propylene glycol, polysorbate or fatty oil, so that handling and use become easier. Various turmeric oleoresin-based products are marketed in different grades of colour strength. Turmeric oleoresin is used largely in brine pickles and to some extent in mayonnaise and relish formulations, non-alcoholic beverages, gelatins, frozen fish sticks, potato preparations, butter, cheese and ice creams.

Turmeric, especially its powder form is liable for adulteration. Hence, many importing countries have prescribed and statutory specifications for turmeric quality. The PFA rules require ground turmeric to contain not more than 13% moisture, 9% total ash, 1.5% insoluble ash and 60% starch.

Recently, CSIR-CFTRI developed a simple economically viable process which provides a newer method of turmeric processing. The process to obtain turmeric powder directly from the fresh turmeric rhizome has been achieved in a single step avoiding a labour intensive thermal treatment followed by drying in vast fields. This novel process would enable the farmers' to overcome labour intensive process of cooking, which involves not only labour but also enormous amount of agricultural fuel for boiling water and drying of the cooked rhizomes for 20~25 days. The process encourage farmers to think of mechanization, which involve slicing followed by drying turmeric within 8~12 h and reduce cost of processing. Dried turmeric slices will have good keeping quality, with typical turmeric aroma and the finished hygienic turmeric powder, which is free from microbial load.

Chillies

The species *Capsicum annuum* and *Capsicum frutescence* provide the chillies of commerce.

Capsicum annuum: It has a large number of cultivars. *Capsicum annuum* var. *annuum* is the most important economically. The cultivated variety annuum has variability, particularly with regard to the fruits. It is a herb or sub shrub. Erect and much branched, 45-100 cm tall and it is usually early maturing. It is grown as an annual crop. The fruit is indehiscent, many seeded berry pendulous or erect and is usually borne singly at the nodes. It is extremely variable in size shape, colour and in degree of pungency. It is linear, conical or globose. The unripe fruit may be green, yellowish or purplish, ripening to red, orange, yellow or purplish colour. The flattened seeds are pale yellow and are 3.5 mm at their largest diameter. Some fruits like sweet pepper are lacking pungency and the degree of pungency varies from mild to very pungent.

Capsicum frutescens: This species is referred as the bird chilli. It is a short lived perennial sub-shrub, 0.5-1.5 m high, living for 2-3 years and is late maturing. The fruits are usually small and narrow, 0.7-30 cm long and 0.3-1.0 cm wide but larger fruited forms do grow. They are extremely pungent. The fruits are green and yellow when mature and are usually red when ripe. Forms with globose, sub conical larger fruits are known .The pale yellow seeds are 2.5-3.5 mm at their greatest diameter.

Cultivation and processing: The chilli plant grows best in well drained heavy or red loam soils, as rain fed or irrigated. Seedlings are raised in nurseries and when 6-7 weeks old, transplanted to the fields. Flowering takes place when the plants are 2-3 months old. Harvesting commences after another three months when the green fruit becomes ripe and turn red. Several pickings are made at intervals of 5-10 days. Irrigated crops require a longer time to grow and give much higher yield than rainfed crops. The yield from rainfed fields may be 500-1000 kg per hectare. The harvested fruits are heaped indoors for 2-3 days till the fruits are uniformly ripened and turn red in colour. Then they are spread out under sun for drying which may take 8-15 days, depending upon the weather conditions. Yields of 25-30% of dry chilli are obtained, based on fresh weight. After drying the chilli is cleaned of extraneous matter, damaged and discoloured pods *etc*. and then bagged. Fumigation is carried out in store to prevent insect infestation.

The dried chilli is a brownish-red to red, conical fruit, 1-15 cm in length. Its base is blunt and the apex sharp and pointed. The calyx and stalk are attached to the fruits. It contains on an average, moisture 10%, fibre 20%, protein 14.5%, non–volatile ether extractives 16.5%. In the fruit, pericarp accounts for 48.5%, seed 44.5% and stem 7.0%. The fruits give a very small amount of volatile (0.5-0.8%) ether extract. However no essential oil containing the aromatic principle has been isolated. The pigment content of chilli is 0.2-0.5%. The principal colouring matter is carotenoid pigment, capsanthin (3.5%) and others being carotene, capsorubin, zexanthin, cryptoxanthin *etc*. Colour deterioration in the fruits and powder is attributed to the oxidation of pigments which is influenced by moisture, storage temperature and light. The pungent principle in chilli is capsaicin, which is present to an extent of 0.2-1%. It is an alkaloid with the molecular formula $C_{18} H_{27}No_3$ and is a substituted benzyl amine derivative.

Chilli oleoresin: Chilli and chilli powder are amenable to infestation mould attack and also discolouration and loss of flavour during storage. These difficulties are eliminated by conversion to oleoresin. Further, oleoresins offer a convenient way of standardizing the quality and strength of flavour. For oleoresin extraction, yield of non–volatile extract, colour and pungency are important factors. Solvent extracted chilli oleoresin is in food demand for food flavourings.

Large cardamom

India is the main producer and exporter of large cardamom. The crop is known by different names in different countries. India is a traditional exporter of cardamom to the Middle East countries, Japan, Russia, Pakistan, Afghanistan, Singapore and UK. Pakistan is the single largest market for export. There is preference for scientifically cured quality cardamom with good colour. The major markets in India are Amritsar, Kolkata, Delhi and Kanpur. The major commercial grades are Badadana, Chottadana, Kanchicut and non- kanchicut. India is the largest market for large cardamom produced by Nepal and Bhutan as well. 'Ramsey', Golsey', and 'Sawney' are names that register instant appeal worldwide.

Large cardamom is an economically valuable, ecologically adaptive and agro-climatically suitable perennial cash crop grown under tree shade in the eastern Himalayas. In Sikkim, large cardamom production peaked early in the 21st century, making India the largest producer in the world, but dropped sharply after 2004; Nepal is now the largest producer. This crop is an important part of the local economy, contributing on average 29.2% of the income of households. Farmers and extension agencies have worked to reverse its decline since 2007 and thus, there is a steady increase in production and production area.

Large cardamom is the traditional spice crop which was in its glory during the mid and late eighties. Decline set in after nineties the cause of which is attributed to some disease complex, nutritional factors and inadequate management. The decline has had wide ranging ramifications, disorienting agrarian economy and upsetting cropping patterns. The area of large cardamom has increased to 26.73 thousand ha, as a result of the area expansion mission initiated by the Food Security and Agriculture Department and the Horticulture and Cash Crop Development Department, Government of Sikkim (2003- 04). The total production of large cardamom increased to 3.31 thousand tonnes by 2007- 2008. Similarly, the yield also decreased to the bare minimum (219 kg/ha) during 2007- 08, rose to 230 kg/ha in 2010 and reached 237 kg/ha during 2012-2013.

Conclusion

There has been a shift from cereals to cash crops in the North Eastern states as evident from the decline in the areas of both maize and paddy and increasing area of ginger. The large cardamom still occupies the second position in area after maize and influencing the agrarian economy of Sikkim. Recent constraints in terms of pest and disease incidences, nutritional deficiencies and inadequate management practices have hampered the cardamom production. This calls for policy intervention as well as strengthening extension services to the large cardamom growers as large cardamom has the potential of providing double income to the farmers as compared to other crops. North Eastern Region (NER) has huge potential for spices cultivation. Large cardamom, ginger, turmeric, chilli, black pepper, tejpat *etc.* are the important spices grown in NER. Current produce of farmers in various states does not get adequate marketing and post-harvest support. As spices in NER are cultivated adopting indigenous/traditional farming methods, the spices grown are in organic nature. In order to market the produce as organic, certification is a prerequisite. The Union Government is implementing programmes aimed at development of spices particularly large cardamom and export of potential varieties of ginger (Nadia), turmeric (Lakadong) and chilli (Naga) in NER. There is need to co-ordinate the activities of the central government agencies, the state government, NERAMAC, Spices Board and CSIR-CFTRI in promoting and marketing the spices produced in NER by adopting latest innovations/hygienic practices.

Value addition in spices - Technological advancements

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Spices are an important part of human nutrition and have a place in all types of cuisines of the world. The delightful flavor and pungency of spices make them indispensable in the preparation of palatable dishes. In addition, they are reputed to possess several medicinal and pharmacological properties and hence find position in the preparation of a number of medicines.

Trend in India's spice export

During the year 2016-17, spices export from India was 9,47,790 tonnes valued Rs. 17,664.60 crores equivalent to 2633.30 million US dollars. India commands a formidable position in the World Spice Trade with 48% share in volume and 44% in value (Spices Board 2017). Recent export scenario is projected in table 1.

Table 1. Export details of Indian spices during 2016-17

Item	Quantity (tonnes)	Value (lakh Rs)
Black pepper	17800	114312.50
Cardamom (S)	3850	42150.0
Cardamom (L)	780	8265.50
Chilli	400250	507,075.0
Ginger	24950	25705.0
Turmeric	116500	124189.0
Coriander	30300	29207.50
Cumin	119000	196320.0
Nutmeg & mace	5070	23641.65
Curry powder & paste	28500	59910.0
Mint products	22300	252750.0
Spice oils & oleoresins	12100	230775.0

General trend in the world consumption of spices

In Asia Pacific, spice consumption will increase at the rate of 4% in the coming years. It is predicted that ready to eat meat products will consume 40,000 tonnes of spices in the next five years. Consumption of spices is also expected through savory, snacks, flavors, bakery (ginger, cinnamon, nutmeg), soups and sauces. Considering the vast growing economies of many developing countries, the demand for spices in the form of pastes, pulps and wet seasonings are gaining market.

Spices as nutraceuticals

Spices are reputed to possess several medicinal and pharmacological properties and hence find position in the preparation of a number of medicines. World demand for nutraceutical ingredients is projected to increase 7.0% annually which is calculated as about 23.7 billion US dollars. Global trends in nutraceutical ingredients will result in developing regions achieving faster growth in production and consumption. Naturally derived substances consisting of herbal and spice extracts will be fastest growing nutraceutical ingredient segment. Spices which possess important medicinal properties are illustrated in table 2.

Table 2. Major spices and their medicinal properties

Medicinal property	Spice
Cancer preventive	Ginger, Black pepper, Nutmeg, Cinnamon, Clove, Turmeric, Cardamom, Vanilla, Allspice, Mace
Antimicrobial	Ginger, Nutmeg, Black pepper, Cinnamon, Vanilla, Turmeric, Clove, Allspice, Cardamom, Mace
Anti-inflammatory	Black pepper, Cinnamon, Clove, Turmeric, Allspice, Cardamom
Spasmolytic	Cinnamon, Black pepper, Clove, Ginger, Nutmeg, Turmeric
Antioxidant	Vanilla, Ginger, Black pepper, Clove, Turmeric
Antiulcer	Ginger, Black pepper, Turmeric, Cinnamon, Clove, Nutmeg, Vanilla, Allspice, Mace
Hypoglycemic	Cardamom
Antihepatotoxic	Vanilla
Antiallergic	Allspice
Antimigraine	Turmeric, Allspice, Cardamom, Mace
Antiosteoporotic	Black pepper, Allspice, Clove, Cardamom, Mace
Estrogenic/Androgenic	Cardamom
Immunostimulant	Turmeric, Mace
Antilithic	Allspice
Anti-insomniac	Allspice, Clove, Mace
Antiedemic	Vanilla

Processing and value addition in spices

Value addition in spices is yet another area of activity in which India is moving forward. In the case of spice powders, spice mixtures and spices in consumer packs, India is in a formidable position. Spices thus open up ample opportunity for entrepreneurship and in the export of value added product in the form of extracts or mixtures.

i. Black pepper

Black pepper, *Piper nigrum* L**.** known as the 'King of Spices' is exported as black pepper, white pepper, pepper in brine, dehydrated green pepper, sterilised pepper, pink pepper *etc*.

Post harvest processing

The primary processing in black pepper involves threshing, blanching, drying, grading and packing. Dipping harvested green pepper for a minute in boiling water enhances the enzymatic oxidation and provides a shining black colour to the produce. Sun drying is the conventional method followed for drying of black pepper. Driers developed by various agencies such as solar and mechanical dryers are highly efficient for drying pepper. With a moisture content of 10-11%, black pepper kept in air tight containers can remain viable for many years.

Intrinsic quality

As in the case of other spices, the medicinal property and aroma quality of black pepper is attributed to the volatile oils present in black pepper. The non-volatile part of black pepper is extracted using organic solvents called the black pepper oleoresin. The major pungent alkaloid present in pepper is piperine. In general, black pepper contains about 3-5% volatile oil, 8-16% oleoresin and 2-6% piperine. Some of the traditional varieties like Kottanadan and Kumbhakodi are rich in oleoresin and piperine. Some of the new varieties with high quality are IISR Malabar Excel, Sreekara and Subhakara. Chemical quality standards or international trade fixed by Codex for black, white and green pepper (BWG) is depicted in Table 3.

Table 3. Chemical characteristics for BWG whole peppers-Codex

Chemical characteristic	**Black**			**White**			**Green**
	Class I/ Grade I	Class II/ Grade II	Class III/ Grade III	Class I/ Grade I	Class II/ Grade II	Class III/ Grade III	
Moisture % (m/m), max.	12.0	12.0	13.0	12.0	12.0	13.0	12.0
NVEE, %.	7.0	7.0	6.0	6.0	6.0	6.0	0.3
Volatile oils, % (ml/100 g).	2.0	1.5	1.0	1.5	1.5	1.0	1.0
Piperine % (m/m),	3.5	3.0	2.0	4.0	3.5	3.0	NA
Total ash, %	6.0	7.0	7.0	3.5	4.0	4.0	5.0

NVEE- Non volatile ether extract

A variety of products have been made from pepper are classified as 1) Green pepper based products 2) Black pepper and white pepper based products 3) Pepper by- products.

Green pepper based products

Major green pepper based products are Canned green pepper, Green pepper in brine, Bulk-packaged green pepper in brine, Cured green pepper, Frozen green pepper, Freeze dried green pepper, Dehydrated green pepper, Green pepper pickle, Mixed green pepper pickle, Green pepper sauce and Green pepper-flavoured products**.**

Black pepper based products

Black pepper based products include Whole black pepper, Sterilized black pepper, Ground black pepper, Cryoground black pepper powder, Pepper oil and Oleoresin.

White pepper based products

White pepper is the white inner corn obtained after removing the outer skin or pericarp of pepper berries. The traditional method of preparation of white pepper is by retting ripened red berries for 8-10 days. Retting converts only ripe and fully mature berries to white pepper. Conversion of harvested berries to white pepper gives a recovery of 22 to 25%. White pepper is preferred over black pepper in light colored preparations such as sauces, cream soups *etc.* where dark colored particles are undesirable. It imparts modified natural flavour to food stuff.

Sterilized pepper

Sterilization of pepper is done to ensure high quality, contamination free, cleaned and dried pepper. Several methods are available for sterilization including hydrostatic/pressure sterilization, ozone sterilization, irradiation, microwave heating, alcohol vapour treatment, steam treatment and fumigation. Continuous steam sterilization method, involve subjecting the spice to a rapid flow of superheated steam for a predetermined period of time followed by drying, re-humidification and packaging. Microbial levels as well as enzyme activity are considerably reduced to low levels and no significant oil or flavour loss is reported. In countries where sterilization by radiation as well as chemical methods is not permitted, steam sterilization is the best

Pepper oil

Pepper oil is used in perfumery and also for manufacturing soaps.

Spice mixtures and blends

Curry powders and spice blends for various culinary uses, pepper flavoured products, products such as pepper mayonnaise, pepper cookies, pepper tofu *etc*.

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

ii. Cardamom

Cardamom, known as the 'queen of spices', which belongs to the family of *Zingiberaceae,* is a rich spice obtained from the seeds of a perennial plant, *Elettaria cardamomum* M. Cardamom plants start bearing two years after planting of suckers/ seedlings.

Harvesting

Fruits mature in about 120 days after flowering. Due to prolonged flowering period, cardamom capsules ripen successively at 10- 15 days intervals over an extended period of 8 months (from August to March). Generally harvesting is carried out at an interval of 15- 30 days and completed in 8-9 rounds by hand picking.

Retention of green colour

Soaking of green (wet) capsules immediately after harvesting in anti oxidants like 2% sodium carbonate solution for 10 minutes can fix green colour during subsequent drying and storage. Immature capsules retain greater intensity of green colour.

Curing and drying

Curing may be defined as the process in which the moisture content of freshly harvested cardamom capsules is reduced from 70-80% to 11-12% at an optimum temperature of 45-55^{o}C so as to retain its green colour and volatile oil to a maximum extent. Some of the driers used to dry cardamom are Melccard dryer, Solar cardamom dryer, Mechanical cardamom dryer, Kerosene stove dryer, Diesel dryer and LPG dryer**.**

Packing

The cured capsules are graded using sieves of 8, 7.5, 7 and 6 mm. After grading cardamom need to be stored over a period of time, in double lined polythene bags. Storage rooms should be free from insect damage. Studies have shown that cardamom dried and maintained at or below 10% moisture retains original parrot green colour and avoids mould growth. It is advisable to make use of dried cardamom capsules preferably within 12 months of harvesting.

Products of cardamom

Bleached cardamom

Either the dried capsule or freshly harvested capsules are utilized for preparing bleached cardamom by using Sulphur dioxide, potassium metabisulphite (25% containing 1% HCL for 30 min) and hydrogen peroxide (4-6% at pH 4.0). It is creamy white or golden yellow in colour.

Decorticated seeds and seed powder

Decorticated cardamom seeds generally fetch a lower price than whole cardamom due to loss of volatile oil during storage and transportation. However, a large portion of the cardamom is imported into Western countries to meet industrial and institutional requirements for bulk supply of powdered cardamom.

Cardamom volatile oil

Yield of the volatile oil varies from 3.4-8.6% in seeds and 5.2-11.3% in dried capsules. However, the flavour quality of the oil is attributed to the relative concentrations of alpha terpinyl acetate to that of 1, 8-cineole. Better aroma quality is contributed by low 1, 8-cineole and high terpinyl actate.

Other products of importance

Encapsulated cardamom - Cardamom flavour has been encapsulated which is free flowing, having uniform flavour

- Cardamom tea
- Cardamom coffee
- Cardamom soft drink mix

iii. Ginger

India and China are the world's largest producer and exporter of ginger *(Zingiber officianale* R.). In India, normally harvesting of ginger is done from January to April, varying with the locations. The crop 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 spade or digging fork and the rhizomes are separated from the dried up leaves, roots and adhering soil. Harvesting is to be done from the 6^{th} month onwards when used as green ginger. The quality of ginger is affected by the stage of the harvest and needs to be scheduled for various end uses (table 4).

Post harvest processing

The post harvest processes involved in the processing of matured fresh ginger to dry ginger involves peeling, drying and polishing. Peeling hastens the process of drying and maintains the epidermal cells of the rhizomes, which contain essential oil responsible for aroma of ginger. It takes about 10-15 days for complete drying. The dried ginger presents a brown, irregular wrinkled surface and when broken shows a dark brownish colour. The dry ginger so obtained is known as rough or unbleached ginger. The yield of dry ginger is 19-25% of fresh ginger depending on the variety and the location where it is grown.

Table 4. Stage of harvest of ginger for various end uses

End use	Stage of harvest (months after planting)
Vegetable purpose and preparation of ginger preserve, candy, soft drinks, pickles and alcoholic beverages	4 – 5
Dried ginger and preparation of ginger oil, oleoresin, dehydrated and bleached ginger	8-10
Green ginger, oleoresin and volatile oil High dry ginger & starch and low crude fibre Dry ginger	7 8 8 – 9
Salted ginger High essential oil High oleoresin High essential oil & oleoresin	4 – 5 7 7½ - 8 8
High oleoresin and oil content	9
High crude fibre & low protein and fat Low crude fibre Less fibre & mild pungency	6½ - 7 7 < 7

Ginger products

Products based on fresh ginger

These are salted ginger, ginger candy, ginger paste, crystallized ginger, ginger wine, bleached (lime-coated) ginger, whole dried ginger, sliced and ground ginger

Ginger based beverages

Among spices, ginger has the unique distinction of being used in beverages. Built around the central flavor of ginger and supported by other flavors from fruits, other spice, and herbs, there are two distinct classes of beverages, ginger beer and ginger ale. The principal difference between these two beverages lies in the rather higher gravity and higher extractives. Ginger beer has a complex flavor and cloudy appearance, whereas ginger ale is valued for its sparklingly clear appearance, distinct lemony-aromatic note on the basis ginger aroma, high pungency, and high carbonation. These two classes of beverages are made in a number of variations to cater to individual marker requirements and end users.

iv. Turmeric

India is the major producer and exporter of turmeric at present, even though the crop is grown in several countries *viz;* Pakistan, Malaysia, Myanmar, Vietnam, Thailand, Philippines, Japan, China, Korea, Sri Lanka, Caribbean Islands and Central America. It is estimated officially that about 80% of the world production of turmeric is from India alone.

Post harvest processing

The turmeric crop is ready for harvesting in about 7 to 9 months after sowing depending upon the variety. In India, sowing takes place between June and July and harvesting is done from February to April. Before harvest, the dry leaves and stem are cut close to the ground.

Washing

Rhizomes are separated after digging out from the soil and are kept soaked in water for 5-6 hrs to remove particles of soil, spray residues and non-useful particles attached with the rhizomes are removed. This process can be achieved by soaking and spraying equipment. Spraying is done at low pressure and wide-angle jet or with high pressure jet.

Boiling/blanching/curing

Traditionally boiling is done in metal or mud pots with (three fourth capacity) water from 1 hr to 1.5 hrs. Now steam cooking using TNAU model boiler, tractor operated boiler and solar panel operated boilers are used for curing turmeric. The main colouring principle curcumin is affected by over cooking and under cooking. About 45 minutes to one hour boiling in traditional method is ideal to cook turmeric fingers. Turmeric rhizomes can be sliced and dried for preparing turmeric powder without boiling. Cooking helps in producing a product of fairly uniform color, due to the diffusion. Boiling considerably reduces the drying time both in the sun and the mechanical drier, and also retains the color and the volatile oil at the same level.

Drying

Sun drying in specially prepared toughened earth or cemented yards is the usual practice. Drying is slow and takes 10-15 days for completion. When properly dried, the rhizomes became hard, almost horny, brittle and show uniform yellow colour. Completely dried turmeric holds 6% moisture content.

Polishing

The appearance of dried rhizomes is improved by rubbing them against ground or by trampling to take out the hard layer over them and small roots are removed. By this process colour of turmeric becomes bright or shining. The product is known in the trade as 'polished turmeric'. Manual methods give low output of around 20 kg for 8 h for two persons.

Mechanical polishing drums have been developed for handling large quantities. Mechanical power or steam engines or electric motor is now used for large sized drums (which may be circular, hexagonal or octagonal in shape) when handling larger batches of dried rhizomes. During polishing, scales, rootlets and some of the epidermal layer are removed as dust through the sieve mesh and surrounding the polishing drums and the sieved dust is generally used as manure.

Colouring

Better look for exported turmeric is imparted by a dry or wet colouring process. In the dry process, turmeric powder is added to the polishing drum in the last 10 min. In the wet colouring process, turmeric powder is suspended in water and mixed inside by sprinkling inside the polishing basket. After colouring is complete, these are dried for one week.

Pulverizing/powdering

Traditionally dried and polished turmeric are cut into pieces and beaten in mortar and pestle. After this it is milled or ground with hand operated chakki. Hammer mill is also used for pulverizing. Powder should be so fine that it passes through 300-micron sieve and nothing is left over the sieve.

Packaging

Cured dried turmeric with moisture content of 15-30% is transported in gunny bags to assembling centers where it is further dried, polished and coloured, if necessary. Dried turmeric is graded according to size and stored. Fumigation and prophylactic treatments are routinely given during warehousing and before export. The colour of turmeric has been found to be stable as long as it is not exposed to sunlight.

Value added products

India is the global leader in value-added products of turmeric and exports. Value added products from turmeric include curcuminoids, dehydrated turmeric powder, oils, and oleoresin. Turmeric, like other spices is available as wholes, grinds and oleoresin. The institutional sector in West buys ground turmeric and oleoresins, while in the industrial sector, whole dry turmeric is preferred.

Ground turmeric

Dried turmeric is powdered by disc type attrition mills to obtain 60-80 mesh powder for use in various end products. The rhizomes contain 4-6 percent of volatile oil and there is a great chance of losing the oil when powdered. Since curcuminoids, the color constituents of turmeric, deteriorate on exposure to light and to a lesser extent, under heat and oxidative conditions, it is important that ground turmeric is packed in a UV protective packaging and appropriately stored.

Powdered turmeric is packed in bulk, in a variety of containers, fibre board drums, multiwalled bags and tin containers. The color of turmeric was not affected in any of the packaging or storage conditions upto six months. Turmeric powder is a major ingredient in curry powders and pastes. In the food industry, it is mostly used to color and flavor mustard. It is also used in chicken bouillon and soups, sauces, gravies, and dry seasonings and also as a colorant in cereals.

Turmeric oil

Dried rhizomes and leaves are used industrially to extract the volatile oil. Dried rhizomes contain 5-6% and leaves contain about 1-1.5% oil. It is generally extracted by steam distillation. Super critical extraction using liquid carbon-dioxide is a relatively new extraction technique for extracting volatile oil and oleoresin. The peculiar turmeric aroma is imparted by ar-turmerone, the major aroma principle in the oil.

Turmeric oleoresin

Turmeric oleoresin is the organic extract of turmeric and is added to food items as a spice and coloring agent. Turmeric oleoresin is essentially used in institutional cooking in meat and fish products and certain products such as mustard, pickles and relish formulas, butter and cheese. This is obtained by the solvent extraction of the ground spice with organic solvents like acetone, ethylene dichloride and ethanol for 4-5 hours. It is orange red in colour. Oleoresin yield ranges from 7.9 to 10.4%. Curcumin, the principal coloring matter forms one third of a good quality oleoresin.

Curcumin

Curcumin or curcuminoids concentrate, for use as a food color, is not a regular article of commerce, because for most current uses the cheaper turmeric oleoresin has been found suitable. Curcumin is included in the list of colors with a restricted use because it has been allotted a low ADI (Acceptable Daily Intake) of 0-1.0 mg/kg body weight/day. Curcumin gives a bright yellow color even at doses of 5-200 ppm. A variety of blends are available to suit the color of the product.

Value added products from other spices

Variety of products that can be made from other spices are listed in Table 5.

Table 5. Value added products from spices

Spice	Value added product
Chillies	Paprika oleoresin, chilli colour, chilli pungency, dehydrated chilli, canned chilli, brined/pickled chill fermented chilli, brined/pickled chilli, fermented chillies.
Nutmeg	Nutmeg powder, nutmeg oleoresin, nutmegs butter, mace oleoresin mace oil
Cinnamon	Cinnamon bark oil, cinnamon oleoresin, cinnamon leaf oil, cinnamon powder, cinnamon root bark oil
Clove	Clove powder, clove oil

Conclusion

Encouraging the preparation of value added products from major spices is aimed at increasing the revenue of farmers from spices other than selling the primary produce. Considering the spectacular growth in the demand for nutraceuticals world over, we can expect a huge jump in the export of curry powders and other value added products in the coming decade**.** The research programmes should orient for this demand by focusing more attention on better agro techniques in product diversification, varieties suitable for such products and adopting GAP. It is the responsibility of different R and D organizations to organize training to farmers to give them confidence to venture in to the area of value added products as a tool to double their income.

ORAL PRESENTATIONS

OP19

Maturity studies of ginger: Variations in ginger oil composition and 6-gingerol content

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Ginger (*Zingiber Officinale* Roscoe) rhizomes have been broadly used as a spice in large part because it's a unique and desirable taste and aroma. 6-gingerol is one of the highly demanded bioactive compounds which have significant antioxidant activity, and it differs with variety to variety and also with maturity stages. Hence, the present investigation focused on the effect of variety and maturity on 6-gingerol content. Ten commercial cultivars of ginger were collected from ICAR-IISR, Calicut and evaluated for 6-gingerol content. The best variety, *i.e.* Rio-de-Jenero was selected based on antioxidant activity and 6-gingerol content. Rio-de-Jenero variety cultivated in Mysore and every thirty days of interval (after flowering), collected the whole ginger plants along with rhizome and analysed for its physicochemical properties. Fresh ginger was used for volatile oil extraction and examined by GC, GC-MS and non-volatile compounds were estimated by TLC and HPLC. Results concluded that, among all ten varieties, Maran variety recorded highest yield of ginger oleoresin (11.05%) followed by Rio-de-Jenero variety (10.5%). Maximum gingerol content was observed in Rio-de-Jenero variety (7.59%). Rio-de-Jenero variety showed a gradual increase in weight of the rhizome (200-700 g) and 6-gingerol content (1.26-4.28%) with increasing maturity, but the weight of leaf, stem and flowers was declined. Volatile oil and oleoresin contents did not cause significant changes in yield (1.02±0.2 and 6.5-7.0% respectively). Fifty constituents were identified by GC-MS, which accounted for 95.24 % of the oils, and major volatile compounds identified were zingiberene (18-20%), ar-curcumin (12-13%), camphene (9-10%) and sequiphellandrene (7-8%).

OP20

Effect of slicing and curing on the quality of turmeric

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Curing is the most important step in the processing of turmeric which is done to reduce the drying time. In the present study, turmeric variety Alleppey Supreme was cured for 60 minutes by traditional water boiling method and in TNAU model turmeric boiler and compared with the third process where the turmeric rhizomes were sliced to 5 mm and all the samples were sun dried. The drying characteristics curves of turmeric rhizomes cured by traditional water boiling method (60 min) showed that the moisture content decreased from an initial moisture content of 418.96% (d.b) to final moisture of 11.41% (d.b) and it took 10 days (240 h) for drying. While turmeric rhizomes cured in TNAU turmeric boiler took 12 days (288 h and the sliced samples dried in 5 days (120 h). Quality analysis of the dried turmeric samples indicated that the maximum retention of primary metabolites *i.e.* carbohydrates, proteins, fat and starch was found in turmeric samples cured by water boiling method and the lowest values of primary metabolites were observed for sliced samples. Variation in secondary metabolites of cured samples in comparison to sliced

samples indicated that maximum retention of secondary metabolites was observed in sliced samples. The results of the study on effect of slicing and curing methods in turmeric indicated that slicing significantly reduced the drying time to 5 days.

OP21

Novel innovations in extraction and value addition to coriander foliage

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Coriander (*Coriandrum sativum* L.) foliage is an important spice crop belonging to family *Apiaceae*. The characteristic aroma, flavour and rich green colour of coriander are vital for its culinary and market importance. This study was conceptualized and implemented to investigate ionic liquid-based microwave-assisted extraction (IL-MAE) and value addition to coriander foliage. A new molecule heneicos-1-ene possessing antioxidant as well as antimicrobial activity was isolated, identified and elucidated structurally. The extraction of hencos-1-ene was carried out using IL-MAE. An optimal condition of 800 W at 90 °C for 2 minutes with material: solvent ratio (1:10) was obtained for IL-MAE by response surface methodology using Box–Behnken design. IL-MAE resulted in higher yield (412.8 mg/100 g) of hencos-1-ene as compared to conventional (69.77 mg/100 g) extraction method. Optimization was carried out to obtain optimal drying as well as pre-treatment conditions to retain higher quality parameters in coriander foliage. Optimum drying was obtained using low-temperature low humidity dryer (50˚C) and pre-treatment condition which includes hot water blanching using 0.1% Na_2CO_3 for 20 seconds at 100˚C. Finally, a technological intervention combining an optimised drying and pre-treatment conditions were executed to obtain hygienic shelf stable green dried coriander foliage. A value added panipuri spice mix with natural coriander flavour and green colour was developed. Storage studies showed slight degradation of quality parameters at 27°C as compared to 37°C of storage and the mix was microbiologically safe as well as sensorily acceptable at the end of 60 days.

OP22

Innovations for healthy hydration: A spicy approach

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Dehydration causes fatigue, cramping, and reduces the ability to function physically. Herbs and shrubs possess medicinal compounds/bioactives which can be used for flavouring water. Tulsi (*Ocimum sanctum* Linn) is shown to counter metabolic and psychological stress; it also has a broad-spectrum of antimicrobial activity, suggesting that it can be used as a mouthwash, water purifier as well as wound healing. Hence this was chosen for preparation of herbal water. The herbal water was prepared by adding emulsified basil oil and camphor using RO water. This was analysed for sensory and microbiological quality. Storage studies were carried out in PET bottles. GCMS profile of basil oil showed the presence of about 12 major compounds, of which methyleugenol (28%),

caryophyllene (18%), eugenol (13%) and cyclohexane (11%) were prominent. Microbial analysis showed that *E coli*, *Salmonella*, yeast and molds were absent in herbal water. This could be attributed to the anti-microbial properties of both basil oil and camphor. Sensory analysis showed that the prepared herbal water had a floral, taste along with basil and camphor aroma giving it a balanced herbal flavour. Storage studies showed a marginal decline in basil flavour and increase in camphor flavour. Thus herbal waters enriched with traditional natural herb extracts with improved flavour can be prepared to suit the Indian market. Naturally flavoured herbal water is a luxurious concept for the Indian market targeted for consumers who believe in healthy indulgence.

OP23

Supercritical fluid extraction technologies: A superior alternative to the conventional techniques for spices extraction

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Spices are used for flavour, colour, aroma and preservation of food or beverages. Spices may be derived from many parts of the plant: bark, buds, flowers, fruits, leaves, rhizomes, roots, seeds, stigmas and styles or the entire plant tops. Spices oils and oleoresins accounts for above 80 % of the export of earnings from value added spices. Supercritical fluid extraction (SFE) is one of the relatively new efficient separation method for the extraction of essential oils from different plant materials. The new products, extracts, can be used as a good base for the production of pharmaceutical drugs and additives in the perfume, cosmetic, and food industries. SCFE is a two step process which uses a dense gas as a solvent e.g., carbon dioxide (CO_2) for extraction, above its critical temperature (31° C) and critical pressure (74 bar). The feed, generally ground solid, is charged into the extractor. Supercritical CO_2 is fed to the extractor through a high pressure pump (100-500 bar). The extract laden CO_2 is sent to a separator (60-120 bar) via a pressure reduction valve. At reduced temperature and pressure conditions, the extract precipitates out in the separator. The extract free CO_2 stream, leaving the separator is then recycled to the extractor. In the case of liquid feed, the extractor is modified into a column through which feed and the supercritical CO_2 is fed either cocurrently or concurrently. These technologies could provide in the next few years an innovative approach to increase the production of spices extract and oleoresin.

POSTER PRESENTATIONS

PP59

Post harvest management and value addition of black pepper (*Piper nigrum* L.)

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The world spices trade is mainly concentrated on black pepper (*Piper nigrum* L.) in the international market both in terms of quantity and value and hence pepper is called the "king of spices". Pepper is used in certain tonic and also used as flavour ingredient in food products including non-alcoholic beverages, meat and meat products, cheese, condiments and relishes. In terms of total area, India ranks first and as for as productivity (315 kg/ha) is concerned India is in the last position. Post harvest operations like harvesting, procession, packing, extraction and development of value added products etc. play a major role in maintaining quality of spices to the specifications of international trade. In addition to reducing the labour, mechanization helps in maintaining the quality and food safety standards. Improvements in hygiene, packing and storage facilities will not only help in keeping quality of spice flavours but also play a major role in reducing aflatoxin and *Salmonella* contamination of spices and spice products. To upgrade pepper industry in India proper measures have to be done. Post harvest management and value addition can help to a great extent in the process.

PP60

A new cardamom dehydrator with better quality

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Drying the fresh cardamom to a safe moisture content is very essential for better shelf life. The color aroma and the volatile retention are the main parameters which decide cardamom pricing. Planters dry cardamom in hot air dryers, using firewood as the source of fuel. In Idukki district, Kerala every year planters use 1.5 lakh tons of fire wood for drying cardamom which emits more than 2.5 lakh tons of CO_2 to the atmosphere. Also, we have lost 7000 sqkms of forest in the last 6 years. Keeping these points in view, we have invented a new dryer and a processing technology based on low consumption of electric energy. Cardamom dried using method had high dry recovery and low moisture content. For every batch of 500 kgs of fresh cardamom, this method of drying yielded 2 to 10 kgs excess dried cardamom compared to traditional method. Advantages of drying using this method include high colour retention, increased dry recovery of capsules, high volatile content, less shrinkage, long shelf life and income enhancement.

PP61

Essential oil content in large cardamom (*Amomum subulatum* Roxb.) grown in Sikkim Himalayas

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Amomum subulatum Roxb. is known for its essential oil having aroma and possesses medicinal properties. An experiment was conducted to study the volatile oil content of large cardamom varieties, *i.e,* Sawney, Golsey, Ramsey and Saremna. In each variety, the samples were collected from six different places. Each sample was analysed for volatile oil content using Clevenger apparatus. The essential oil content varied from 2.7% to 1.9% in large cardamom varieties. Among all varieties analyzed, higher oil content was found in Golsey 2.7% followed by Ramsey 2.1%, Saremna 2% and Sawney 1.9%. Hence, the variety Golsey can be recommended for Sikkim.

PP62

Studies on declining large cardamom (*Amomum subulatum* Roxb.) cultivation in Sikkim

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Large cardamom (*Amomum subulatum*) is an important cash crop of North Eastern Himalayan region including Sikkim and Darjeeling hills. Sikkim is the largest producer of large cardamom in India. Almost half of the population in the region dwells their living on the cultivation of large cardamom. A survey was conducted in large cardamom growing regions of Sikkim to find out the reason for declining productivity in the region. It was observed that the production of this crop has declined rapidly since past decade due to the infestation of fungal diseases - a major threat to the crop. The disease appears generally with the beginning of pre monsoon showers followed by sunny days of rainy season. Focus of this study was to manage the disease with locally available botanicals in the region - an ecofriendly sustainable approach.

PP63

An isoxazoline route to the synthesis of [6]-gingerol amino acid conjugates

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The library synthesis of new compounds derived from [6]-gingerol, a valued nutraceutical principle of ginger (*Zingiber officinale*), is least explored due to its low commercial availability and

instability. In this work, the synthesis of [6]-gingerol amino acid conjugates was accomplished and its influence on the bioactivity profile has been accounted. To attach the amino acids to [6]-gingerol, the phenolic group was chosen while the secondary hydroxyl in the side chain was protected in the isoxazoline cyclic form. The isoxazoline plays an important role as it protects the side chain hydroxyl and it can also be de-protected easily by reductive cleavage after the amino acid is attached. Amino acids (valine, proline and isoleucine) were attached to the free phenolic by acylation using EDC reagent. [6]-Gingerol isoxazoline was first synthesized from eugenol and later gingerol amino acid conjugates were obtained. In the approach, Boc-protected amino acids namely valine, isoleucine and proline were conjugated with [6]-gingerol isoxazoline and the de-protection of Boc-group was carried out using trifluouroacetic acid. The isoxazoline moiety was stable at this stage while free form of β-hydroxy group in gingerol is not. Hence, isoxazoline route affords a feasible approach to the synthesis of [6]-gingerol amino acid conjugates.

PP64

Post harvest management, value addition and marketing of ginger (*Zingiber officinale*) – A review

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Ginger is an important spice crop in the world, which is known for its medicinal and aromatic properties. India is one of the leading country in producing and exporting of ginger. The chemical component gingerol along with its derivates like gingiberone, geranial, linalool, camphene *etc.* account for the characteristic medicinal and aromatic properties of ginger. Fresh ginger being perishable in nature seeks proper post harvest management practices and thus value addition of ginger turns out to be an effective alternative to fetch maximum return to the growers. Different value added products that can be prepared from ginger are ginger pickle, dried ginger, ginger powder, ginger candy, ginger paste, ginger oil and oleoresins. These value added products can be exported locally and globally for a beneficial income. Keeping in view of this, a review has been made regarding post harvest management, value addition and marketing of ginger.

PP65

Comparison of crystalline curcumin and its nanoformulation for its bioactivity

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Turmeric (*Curcuma longa*) has been found to have medicinal effects due to the presence of curcumin, the bright yellow diarylheptanoid that gives turmeric its colour. Curcumin possesses strong anti-oxidant and anti-diabetic properties. However, curcumin is unstable and non-bioavailable in the human body. If made available to the body, it can potentially prevent as well as cure several diseases and also act as a health supplement. Generally oleoresin is prepared from dried turmeric powder using organic solvents, which is further used for extracting crystalline

curcumin. Crude curcumin or oleoresin was obtained by acetone extraction from turmeric. Curcumin was crystallised out of this crude mixture by solubilising the mixture in methanol and water followed by cooling. To enhance the bio-availability of curcumin in the body, it was made into nano scale by subjecting the crystals to ultra sonication in the presence of a stabilizer. The mixture thus obtained was visualized under Scanning Electron Microscopy (SEM), from which its shape and size were analyzed. The particles were compared to the size of standard curcumin crystals in the same magnification to visualize the difference in size. The crystals in the solution had their sizes ranging from 50-200 nm, and they were viewed in several magnifications ranging from 1000x to 50,000x. The optimization of nano-formulation process to form a consumable product is under progress.

PP66

Diversity of curcumin & curcuminoids in turmeric (*Curcuma longa* L.) genotypes

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Turmeric (*Curcuma longa* L.), the wonder spice is bestowed with multiple applications as culinary spice, cosmetic, natural dye, nutraceutical and as an ingredient in traditional and complimentary medicines. The major constituent contributing to all these properties is curcumin and the level of curcumin varies with different genotypes. Seventy germplasm accessions of turmeric including fifteen popular cultivars were evaluated for curcuminoid content and distribution of individual curcuminoids in rhizomes during 2016-17. Curcuminoids were estimated by two methods namely, spectrophotometry and HPLC analysis. Total curcuminoids and curcumin varied between 2.0-6.47% and 1-4% respectively. Distribution of minor curcuminoids namely, demethoxy curcumin and bis-demethoxy curcumin were also determined.

PP67

Extractability of curcumin in various vegetable oils

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Turmeric (*Curcuma longa* L.) is known for its therapeutic properties. Curcumin, the principal curcuminoid, which constitutes upto 2-5% of the rhizome contribute to such properties. Curcumin which is hydrophobic in nature, is soluble in dimethyl sulfoxide, ethanol, acetone and oils and has an absorption maxima around 425 nm. Studies show that a significant amount of curcumin can be extracted in various edible oils such as virgin coconut oil, olive oil, soybean oil, linseed oil etc. The bioavailability of curcumin in human body is expected to be higher when dissolved in oils. In the current study, turmeric powder (variety Prabha), freeze dried fresh turmeric juice powder and residual press cake were compared with authentic curcumin for its solubility in Virgin Coconut Oil (VCO) and olive oil. The strong antioxidant properties of both virgin coconut oil and olive oil make these oils a fine choice for this experimental study. Optimization studies were carried out by varying time, temperature and quantity of the samples while heating, powdered samples mixed in

the oils, over a boiling water bath. Extractability was more prominent in hot oils compared to ambient temperature. Solubility of curcumin in the oils was measured by quantifying the curcumin content in oil by UV Spectrophotometer using acetone extraction method as control. The results indicated that about 70-80% of curcumin was getting extracted into oils with respect to that in acetone. Curcumin extracted in VCO and olive oil is expected to show more availability compared to normal curcumin intake.

PP68

Freeze dried turmeric juice powder – Comparison of quality profile

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Fresh turmeric juice (var. Prabha) was extracted in a twin screw expeller and filtered to remove the fibrous particles. The juice was frozen at -47°C for 4 h and freeze dried under vacuum. The residue obtained after the juice extraction was dried in an oven. Essential oil profiling of freeze dried turmeric powder was done using GCMS. Microcrystalline structure of the powder sample was analyzed in field emission Scanning Electron Microscope (SEM). The results of the study showed that the dry recovery of freeze dried turmeric powder was 4.31% with a moisture content of 1.02%. Quality analysis of freeze dried turmeric powder in terms of its essential oil, oleoresin and curcumin content were 2.0, 20.10 and 1.57%, respectively and that with the press cake were 6.0, 13.98 and 6.55%, respectively with dry recovery of 19.37% having moisture, 8.42%. The initial quality parameters of oven dried turmeric powder in terms of its essential oil, oleoresin and curcumin content were 4.8, 13.68 and 6.46% with a dry recovery of 13.97% and 9.88% moisture content. Oil profiling for volatile oil of freeze-dried turmeric powder indicated the presence of Ar-turmerone (43%) and Curlone (19%) in its peak level. The results for the SEM structure analysis for fresh turmeric powder showed no sharp peak, indicating its amorphous nature.

PP69

Influence of processing methods on the quality attributes of turmeric (*Curcuma longa* L.)

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Turmeric (*Curcuma longa* L.) also called Indian saffron, is mainly valued for its attractive colour which is imparted by a group of compounds known as curcuminoids. Curcuminoids comprise of three major components, namely, curcumin, demethoxy curcumin and bisdemethoxy curcumin of which curcumin is predominant. The level of curcuminoids and other secondary metabolites depends on genotype, location, maturity and post harvest processing methods. The effect of two processing methods on the essential oil, oleoresin and curcuminoid content in four genotypes is reported here.

PP70

Processing of tikhur (*Curcuma angustifolia* L.) and its value addition

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Curcuma angustifolia is an underutilized rhizomatous herb, commonly found growing in India, especially in the north east and western coastal plains and hills. The traditional processing of tikhur rhizome into tikhur starch is a cumbersome, tedious and time consuming process. The present study focused on development of a simple solution for effective debittering and its value addition. The debittered starch flour was obtained after treating with potassium meta-bisulphite, gelatin and sodium hydroxide, under varying concentration. The processed starch had small, medium and big size granules with amylose content of 21-27% and gelatinization temperatures in the range of 64–73 °C. Milk barfi and soup were prepared using debittered starch as main ingredient and consumer acceptance study was conducted using 7-point hedonic scale. Results indicated that, 47% rated the products as 'Like Very Much' (LVM), 39% rated 'Like Moderately' (LM) and 16% rated as 'Like Slightly' (LS). Since all the ratings have fallen on the 'Like category', the sample is acceptable. The product deteriorative characteristics were studied and economical feasible package on basis of moisture content and relative humidity (RH) was designed to get more than a year, shelf life. The results indicate that, the product has moisture tolerance of more than 5%. Hence, the product is shelf stable. Critical relative humidity 79% at and below 70% RH the product needs to be packed for easy handling, utilization, transportation, hygiene and to keep the brand name. Hence, 250-300 gauze or 60-75 µ LDPE can be used.

PP71

Quality evaluation of turmeric cured in concentrated solar thermal turmeric curing unit

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Curing of turmeric (*Curcuma longa*) is the most important step in the processing of turmeric. In the present study, turmeric variety-Alleppey Supreme was cured in the newly developed concentrated solar thermal turmeric curing unit utilizing solar renewable energy. The unit consists of 16 parabolic trough collectors each of size 2 x 1 m made of anodized aluminium with weather proof physical vapour deposition (PVD) coating and can generate about 150°C/ 3.5 bar saturated steam. A micro controller based single axis tracking system with Global Position System (GPS) is employed to achieve continuous and automatic tracking. Fifty kg of washed turmeric was taken in the curing vessel and the experiments on curing of turmeric were done by using concentrated solar thermal curing unit for six different time intervals (15, 30, 45, 60, 75 and 90 min) and then sun dried. The time required for drying turmeric cured for 15 min in concentrated solar thermal turmeric curing unit was 21 days (504 h) and minimum period of 9 days (216 h) was required for drying turmeric when it was cured for 90 min. Turmeric cured by traditional water boiling method for 60 min took 10 days (240 h) and that cured by TNAU turmeric boiler took 12 days (288 h) for drying. The study concluded that curing of turmeric in concentrated solar thermal turmeric curing

unit fitted with cooking vessel for 60 min was considered optimum based on the maximum retention in the essential oil content and the minimum drying time required.

PP72

Status of turmeric industry in Maharashtra

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Turmeric is one of the important spice crop of Maharashtra mainly cultivated for its underground rhizomes. It is grown in an area of 11241 ha with annual production of 186751 MT (2017-18). The major limiting factor in the turmeric cultivation is the unavailability of the quality planting material of improved varieties. More than 80% area is under the traditional Salem variety. The seed replacement ratio is very low due to high seed rate which contribute more than 30% of cost in cost of cultivation. The trend of organic cultivation of the turmeric is increasing day by day but the organic cultivation of turmeric is having its own limitations especially in the control of the pest and diseases as well as marketing of the organic turmeric. The introduction of the steam cookers for processing of turmeric has improved the quality of turmeric. Sangli is one of the oldest markets for trading of turmeric. However, it is still unorganized and monopoly of the traders resulted into less prices to the farmer's. The facilities available at Mumbai port as well as promotional schemes from Spice Board of India opened the doors for export. The Spices Board of India, State Agricultural Universities and Department of Agriculture, Government of Maharashtra are coordinating for increasing the area of turmeric in Maharashtra. By considering the climatic conditions of Maharashtra, there is wide scope for expansion of turmeric area in Maharashtra which will be helpful for doubling the farmer's income.

PP73

Effect of dietary supplementation of cinnamon on performance of broiler chicken

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The objective of the study was to find out the dietary supplementation of cinnamon at different levels on the performance in terms of growth, feed intake, carcass characteristics, overall performance and cost of rearing of broiler chickens. A total of 120 birds were divided randomly in to four treatments with five replications consisting six birds each. The chicks in T_1 (Control group) were provided with standard broiler starter and broiler finisher diet from 0-21 and 22-42 day, respectively. The chicks of the other groups were also offered with same diet as in T_1 along with cinnamon powder @2.5 (T_2), 5.0 (T_3) and 7.5 (T_4) g/kg diet for a period of 42 days. Weekly body weight and daily feed intake was recorded replication wise. Gain in weight and feed conversion efficiency (FCE) was calculated accordingly. On 42 day, 2 birds from each treatment were sacrificed to study the carcass characteristics. The results showed that low level of cinnamon supplementation in diet had no negative effect on body weight. Cost of production was highest in

T_4 and lowest in T_2. However, net profit per unit of weight was highest in T_1 as compared to other cinnamon supplemented groups. The organoleptic properties of the meat were unaffected due to dietary supplementation of cinnamon. On the basis of the findings, it can be concluded that supplementation of cinnamon at various level had no significant impact on the overall performance of broiler birds over control group.

PP74

In vitro antioxidant, anti-inflammatory and cytotoxic properties in bark and leaf extract of four *Cinnamomum* species

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The antioxidant activities of hexane, chloroform, methanol and water extracts of four *Cinnamomum* species and anti-inflammatory properties and cytotoxic effects of selected extracts were studied. Both bark and leaf extracts of *C. verum, C. cassia, C. tamala* and *C. camphora* were tested *in vitro* for antioxidant potential by DPPH radical scavenging assay, total antioxidant capacity was measured by phosphomolybdenum assay and ferric reducing assay. Total phenol content of each extract was analyzed and correlated with antioxidant potential. Cytotoxicity of selected extracts of *Cinnamomum* species was studied by cell viability assay such as MTT assay on PANC-1 cell lines. Anti-inflammatory properties of selected *Cinnamomum* extracts were analyzed by Cyclooxygenase (COX) activity, Lipoxygenase (LOX) activity, Myleoperoxidase (MPO) activity, inducible nitric oxide synthase, estimation of cellular nitrite levels and the activity was compared with standard drug diclofenac sodium. The results from the present study indicated that extracts of *C. verum*, *C. cassia*, *C. tamala* and *C. camphora* contained compounds having high antioxidant, anticancer and anti-inflammatory potential, which contributes to bioactivitiy of *Cinnamomum* species.

PP75

Leaf cutting (s) of coriander provide extra benefits to the farmer

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Coriander (*Coriandrum sativum*) is an annual herb, mainly cultivated for its fruits as well as for the tender green leaves. The leaves of coriander are used for preparing fresh chutneys and sauces, curries and soup. The fruits are extensively used in preparation of curry powder, pickling spices, flavouring and seasoning of bakery products. These are considered to have carminative, diuretic, tonic, stomachic, antibilious, refrigerant and aphrodisiac properties. Coriander plants have excellent regenerative capacity, and easily respond up to two to three cuttings. Several research reports have shown that leaf cutting can increase the number of branches and umbels per plant which in turn increased the yield of leaves and seeds in coriander, but often the growers are uncertain about the re-growth pattern, and are reluctant to cut multiple times. However, appropriate management techniques to explore the possibility of multiple cutting in coriander will

be of great benefit as it saves cost and time involved in land preparation and sowing which forms a major part in the total cost of cultivation. Therefore, when green leaf yield is the primary objective, the crop should be sown at closer spacing and left for seed production after two cuttings, whereas, in case of seed yield being the primary objective, sowing at medium spacing and taking seed crop after one cutting can maximize financial benefits to the farmer.

PP76

Avenues of value addition in Naga King Chilli for enhancing farmer's income

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Naga King Chilli (Naga Jolokia or bhootjolokia in Assamese vernacular; (*Capsicum chinense* Jacq) has received massive attention among the scientific community throughout the world due to its unique aroma and has been acknowledged as the hottest chilli in the world, measuring 1,001304 Scoville Heat Units (SHU) in the Guinness Book of world records, 2007 and Nagaland Government has obtained the *GI* rights for this product in 2008. Though it has high potential in the national and international market, the market demands are barely met for various reasons amongst which, the post harvest losses is one of the pre-dominant factors. In Nagaland, most of the King Chilli growers cultivate this crop under burned bamboo grooves in the jhum sites, which are in remote and far flung areas. The transportation of the fresh produce from the growing areas to the market becomes a challenge due to the lacuna in the infrastructural as well as the existing road conditions. In order to combat the post harvest losses due to the above mentioned factors, post harvest management, processing and value addition is the need of the hour for tapping the potential of this high valued crop. Value added products such as King Chilli sauces and pickles is a remunerative option during peak season in order to tackle the post harvest losses and enhance shelf value, which in the foreseeable future would definitely double the farmers income.

PP77

Effect of garlic supplementation on the performance, carcass traits and blood profile of broiler chicken

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One hundred and twenty numbers of day old broiler chicks were reared for a period of 42 days under standard management practices to evaluate the effect of garlic on the performance, carcass traits and blood profile. The birds were divided into four treatment groups *viz.,* T_1, T_2, T_3 and T_4 with five replications in each group and were fed with commercial broiler feeds containing 0% (control), 0.25% (T_2), 0.50% (T_3) and 0.75% (T_4) of garlic powder. It was observed that there were no significant differences in body weight, weight gain, feed intake, feed efficiency and mortality among the treatment group except for dressing percentage which was recorded to be better in group T_3. Similarly, supplementation of garlic at the above levels did not show any significant effect

on total red blood cells, white blood cells, packed cells volume, haemoglobin, glucose, differential white blood cells count, serum cholesterol, low density lipoprotein (LDL) and high density lipoprotein (HDL) in the above treatment groups.

PP78

Commercialization of spice cultivation in Assam

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Abstract

Assam is bestowed with varied climatic situation ranging from sub-tropical to temperate situation with about 2000 mm to 2200 mm annual rainfall. The total horticultural cropped area in Assam is about 14.34% of gross national cropped area of which spices occupy a limited area. Spice cultivation in Assam has been spread in an area of 1.22 lakh hectares with a production of 5.35 metric tonnes. Out of the total fifty six spices, mainly grown spices are black pepper, turmeric, ginger, coriander and bay leaves. Though chilli is an important spice crop, the rainy season of Assam make chilli cultivation only meant for fresh consumption. Drying is a problem due to high humidity and wet climate. However, Bird's eye chilli flakes are used in the cuisines of north eastern states like Meghalaya and Assam. Besides this region having immense potential for spice cultivation, there are many constraints acting as hindrance towards its commercialization. Land unavailability is the major constraint. The second major problem islack of high yielding varieties. On the other hand, ginger has a major problem of rhizome rot caused by bacteria and fungi particularly in plain areas which lack drainage facilities. Black pepper may be pushed upward by bringing arecanut plantations with vertical cropping. Coriander as a seed crop coincides with early monsoon. Short duration varieties must be screened first for boosting this crop in Assam.

PP79

Embedded non-yield traits in spices: An analysis of role of varietal technology on sustainability and crop dispersion

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The impact assessment studies on plant breeding efforts have consistently yielded results which show that the rate of return associated with the investments compare favorably with other investment opportunities. Though varietal development is commonly associated with yield enhancement and resultant enhancement in total output, the non-yield traits embedded in varieties also constitute a significant aspect of varietal development efforts. The deployment of traits for pest resistance, disease resistance and particularly abiotic stress tolerance enhance the rate of geographic dispersion of the crop and enhanced sustainability in existing areas. This study examines this hypothesis in selected spice crops.

The non-yield traits of varieties released from ICAR-Indian Institute of Spices Research was compiled to assess the extent and intensity of presence of non-yield traits in spice crops. The varietal technology programme of the institute has succeeded in deploying several non-yield traits across spice varieties. Consequent to the enhancement of crop adaptability through trait deployment, stakeholder farmers should be able to cultivate the crop across a wider range of agro-climatic conditions and thereby reducing the crop concentration in limited geographic region.

Using the all India district wise data on crop area, the impact of these traits on geographic dispersion across districts was measured using by Herfindahl-Hirschman index (HHI) for the two periods 2009-10 and 2014-15. The results show a marked decline in crop concentration in the three spices considered for detailed investigation, *viz*., black pepper ginger and turmeric. A lower HHI indicates more diversified production. All the crops have recorded a significant increase in diversification of production regions between the two periods. Simultaneous increase in area under cultivation with a simultaneous decrease in concentration of production is indicative of wider geographic spread and availability of technology to support crop production activity across wider range of agro-climatic conditions. Crop cultivation across diverse ago-ecological zones can reduce the chances of supply shocks of abiotic and biotic origin in particular crop zones. The study highlights the effectiveness of the stock of varietal technology available to address specific issues when a crop gets cultivated in newer areas which acts as a latent source of technology backup in these crops.

PP80

Value chain of Megha turmeric-1 for doubling farmers' income

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Turmeric has been valued as a source of medicine and colour from ancient times. The crop is grown in an area of 2.17 thousand ha with a production of 12.53 thousand tonnes in Meghalaya (NHB, 2016). During the last decade, the demand for turmeric (fresh & dry) from the state increased substantially. Megha Turmeric-1 was tested under AICRP on Spices at ten (10) locations under different agro-climatic conditions over 5 years. The variety showed high stability in terms of dry yield under various environmental conditions. The variety was stable and identified for high dry yield (16.37% recovery) and curcumin content (6.8%). Front line Demonstrations on this high yielding turmeric were conducted with help of Self Help Groups (57 SHGs in 30 villages). The intervention of this variety led to increase in productivity of fresh turmeric from 10-12 t/ha to 20-22 t/ha in farmers field. The SHGs earned an average net return of Rs. 1,41,604/ha with a high B:C ratio (2.52). To promote value addition, Turmeric Processing Unit (capacity 300 kg dry or 1500 kg fresh turmeric per day) was established at Laskein in Jaintia Hills under a DBT project. This participatory value chain linkage not only increased the productivity and developed entrepreneurship among tribal farmers of Meghalaya, but is also helping in achieving sustainable livelihood.

PP81

Harnessing the potential of spice business in North East India with special reference to Manipur

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To tap North East states' potential to emerge as a destination for cultivation of spices, the Spices Board has embarked on plans to promote farming of a wide range of produce that fetch great demand in domestic and global markets. According to the Board, with Assam in the core location, Arunachal Pradesh, Manipur, Nagaland, Tripura, Meghalaya and Mizoram are congenial grounds for commercial cultivation of spices retaining their unique generic properties. The project is expected to give a fillip to a variety of spices like Naga chillies, highly pungent bird's eye chillies of Mizoram, high curcumin bearing Lakadong turmeric of Meghalaya, Himalayan ginger and large cardamom. To start with, the Board will come up with flagship schemes in Arunachal Pradesh, partnering with the state Horticulture Department, offered to provide critical support like establishing primary processing units closer to production areas for traders and exporters to procure clean spices. The Manipur state also offers a great potential in terms of spice business. Diverse spices are abundantly available in the state for instance Toningkhok (*Houttuynia cordata*), Phak-pai *(Persicaria posumbu*), Mayang-ton (*Ocimum canum*), Mukthrubi mana (*Zanthoxylum acanthopodium*), Lomba (*Anisochilus carnosus*), Pheija (*Wendlandia glabrata*), Chantruk (*Cardamine hirsuta*), Naosek lei (*Ocimum basilicum*) *etc*. which has a high value with least availability making an effective business potential since the demand of such crop is increasing by the people of Manipur.

PP82

Post harvest management and value addition of spices

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Spices are high value export oriented crops and India is a major exporter of spices and spic e products. The present deficiency in on farm primary and secondary processing of spices need to be bridged for quality up gradation and greater emphasis on product diversification to the newer requirements of domestic as well as global marketing. Thus post harvest processing and management of spices have great scope considering the present international trade scenario. Spices are living commodities as they respire. Hence, proper post harvest management handling and processing is required in spice crops. Primary processing of major spices which includes, washing, thrashing, blanching, curing or drying, cleaning, grading and packaging, sometimes special practices are utilized for improving quality of commodities like garbling in cardamom, polishing in turmeric and ginger and killing, sweating and conditioning in vanilla *etc*. The quality of seed spices is assessed by mean of its intrinsic (moisture, volatile oil, oleoresin and major chemical constituents) as well as extrinsic (size, appearance, colour) characteristics. The produce must be

safe, free from any health hazards substances and contaminants. There are several value added product made by raw spices like curry powder, ground spices, spices extractives (oleoresin and essential oil), consumer packed spices and organic spices. Post harvest operations like harvesting, processing, packing, extraction and development of value added products etc play a major role in maintaining quality of spices to the specifications of international trade. In addition to reducing the labour, mechanization helps in maintaining the quality and food safety standards.

PP83

Spices from flowers and flower parts

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India is recognized all over the world as the abode of many spices since time immemorial. The Indian spices occupy a prominent position in the international trade. There are a large number of plants which are used as spices and their uses include medicinal, cosmetic, food products, curry powder, as oil and oleoresin. There are different systems of classifying spices and classification based on plant parts used is one of them like fruit, berry, seed, rhizome, root, leaves, bark, bulb, kernel, aril, pulp / rind, latex and also from flowers and flower parts. Spices from flower and flower parts include common spices like clove, saffron, caper, cassia bud, savory, mint *etc*. It also includes ornamental plants like rose, viola, lavender, jasmine *etc*. There are also lesser known or underutilized herbs and plants found in the north eastern region of the country like *Ocimum basilicum*, *Ocimum canum*, *Anisochilus carnosus etc*. where the flower or flower parts or inflorescence are used as spices. They are traded and consumed locally some of which have high potential for commercialization as they are rich source of vitamins, minerals and phytochemicals apart from their medicinal values.

PP84

Commercialization of aromatic plants in NE region and its impact on livelihood

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Commercial cultivation of aromatic plants is the new trend of agriculture in India. Commercialization plays a vital role in the preservation of aromatic plants that serves a win-win scenario for both cultivar and cultivator. Most aromatic plants find value in industries such as pharmaceuticals, naturopathy, perfume and cosmetics occur in the wild. According to a survey by Ministry of Environment, Forests and Climate Change, Government of India, there are over 9500 species of medicinal and aromatic plants useful for pharmaceutical industries. Out of 880 traded plant species, only 538 plant species occur in the wild and 88 plant species are traded from cultivation. This means a huge chunk of aromatic plants extracted from their wild habitat. Many species of aromatic plants may soon become extinct due to deforestation and loss of natural habitat. Selective or mass cultivation of high value aromatic plants may be helpful for their

preservation. North east India has a huge un-tapped reserve of aromatic plants. But due to lack of proper agro-techniques, marketing strategies and financial support, the growth of aromatic industry in NE region has not received the much needed boost. Though aromatic plants from NE region are exported to other states in India, a localized industrial set-up for skilled extraction of aromatic products will have a beneficial impact on the farmers for the economic growth of this region.

Committee members for National Symposium on "Spices for doubling farmer's income" held during 15 - 17 March, 2018 at SASRD, Nagaland University, Medziphema Campus, Nagaland.

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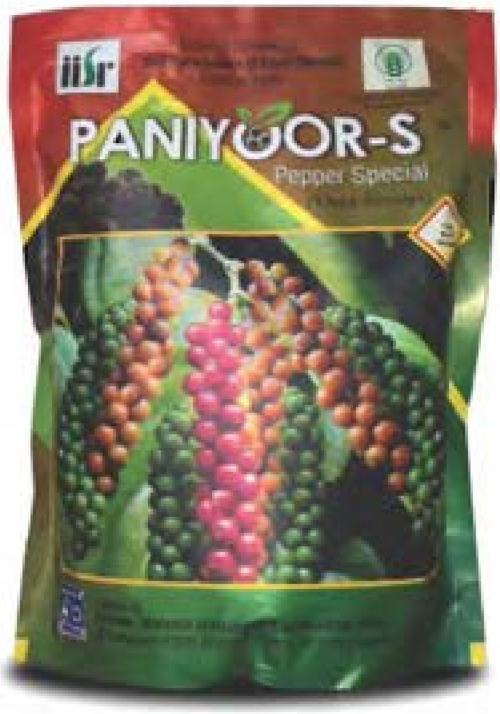

Launching of Paniyoor-S at Indian Institute of Spices Research, Kozikode, Kerala by Principal Soil Scientist, Dr. V.Srinivsan, Ex-Director Dr. M.Anandaraj, Chairman Shrey Agritech Dr. Kiran Anegundi and Principal Scientist Dr.Sheeja T.E

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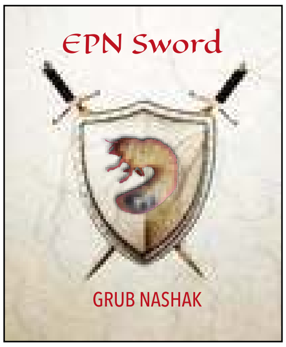

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World Spice Organisation

Joint vision in new direction

The Spice Industry has seen progress at a rapid pace in the past few decades. Today, it is a $3.2 billion, 1 million tons industry. The increasing awareness among world-wide consumers on the wholesome goodness of spices, development of new products, processes and applications have helped the industry scale new heights.

With the global importance of food safety laws increasing, the demand for processed spices is only going to grow. However, there are certain roadblocks which could hamper further growth. They are:

- Disproportionately lower production vis-à-vis increase in population leading to shortage in supply
- Exploitation of soil and environment – inordinate usage of hazardous chemicals
- Poor sanitation & hygiene conditions at farm level
- Rigorous and exacting food safety laws

It is in this backdrop that World Spice Organisation (WSO) comes into existence in Kochi, the spice capital of India.

WSO is a not-for-profit organization registered under the Travancore Cochin Literary, Scientific And Charitable Societies Act, 1956 with the primary objective of facilitating the Spice Industry in dealing with issues of "Food Safety & Sustainability". WSO seeks to achieve its objectives by involving all its stakeholders—the general public, the industry, the academia and the end-users. We also seek to strengthen the 'Corporate Social Responsibility' initiatives of the industry.

WSO recognises that efforts for food safety and sustainability should begin at the farm level. This is because all major issues that threaten the industry today—from lower productivity to the occurrence of harmful agrochemicals—have their roots there.

WSO recognizes the contributions of spice associations and regulatory bodies, in the development of the industry. WSO, therefore will operate through, and together with, all the stakeholders of the industry and national spice associations to address the various issues in the industry, for a spice renaissance ..

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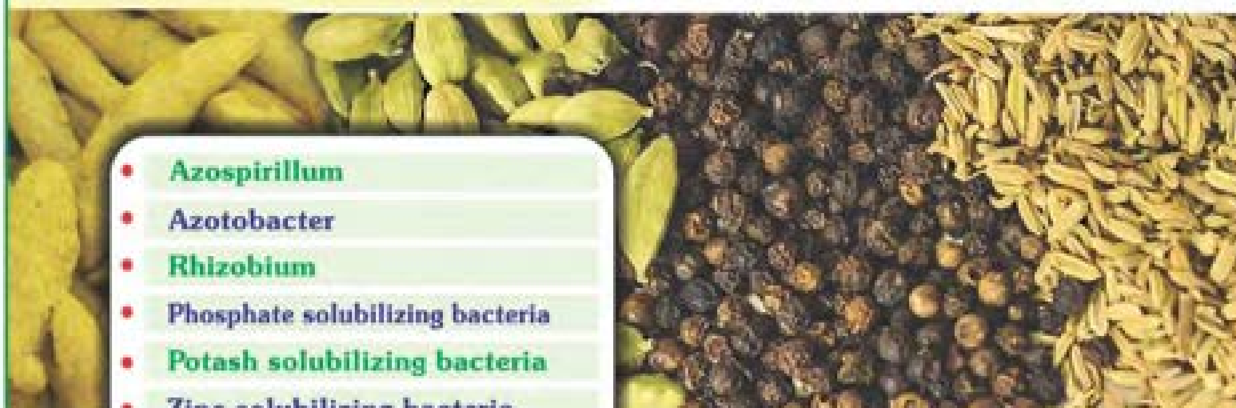

- Azospirillum
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- Rhizobium
- Phosphate solubilizing bacteria
- Potash solubilizing bacteria
- Zinc solubilizing bacteria
- Vesicular arbuscular mycorrhiza (Vam)
- Gluconacetobacter
- Methylobacterium

Bio Control Agents

- Pseudomonas fluorescens
- Trichoderma viride
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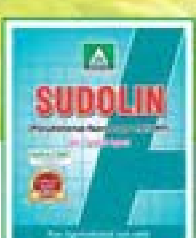

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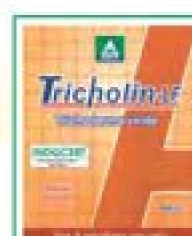

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The Indian Society for Spices was founded in 1991 for the advancement of research and development of spices, aromatic, medicinal and related crops. The society aims at providing a forum for research workers on these crops for exchange of ideas, and as a catalytic link between research and development organizations and the industry. The society organizes symposia, conferences and seminars in collaboration with other organizations on aspects relevant to spices, aromatic and medicinal crops. The society fosters to the professional interest of research workers on spices, medicinal and aromatic crops through its journal, the Journal of Spices and Aromatic Crops, which is available free of cost to members. Members also receive publications of the society at reduced cost and can participate in scientific meetings and other functions of the society.

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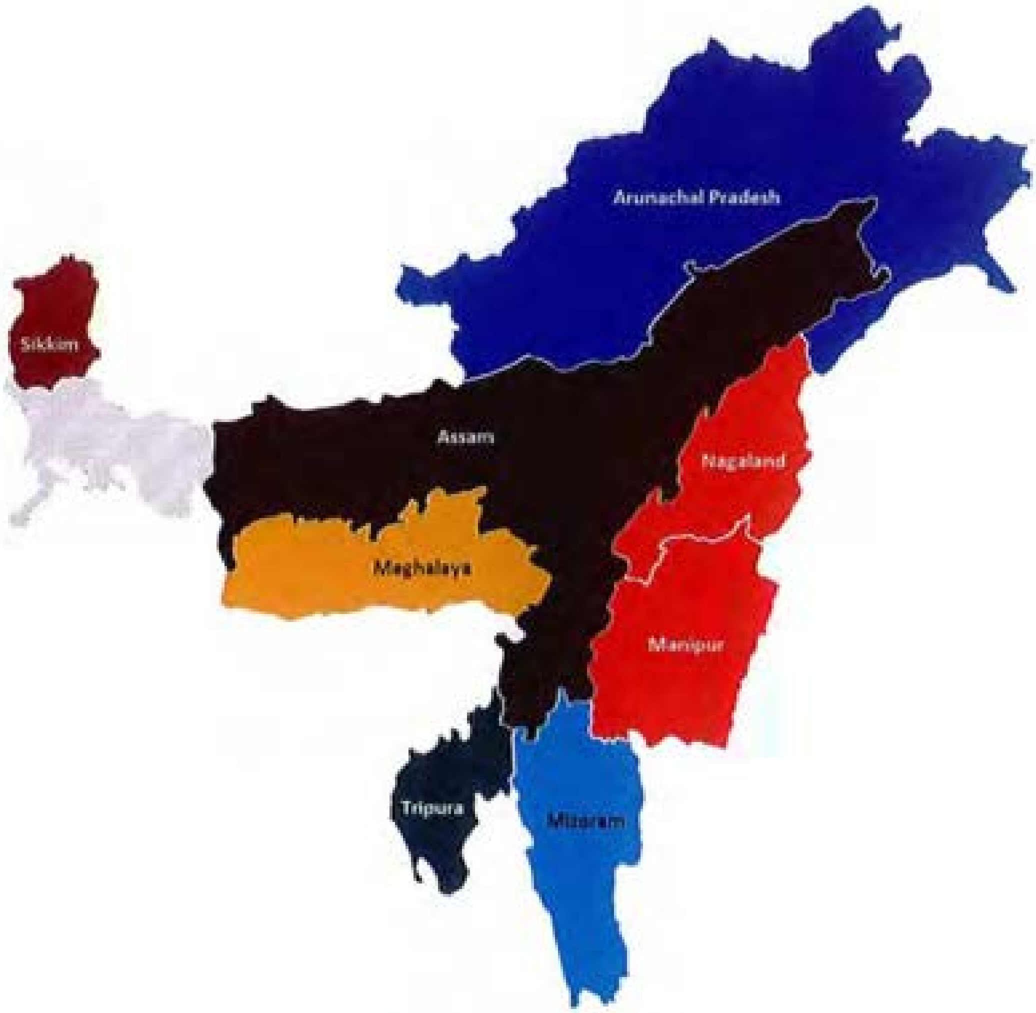

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